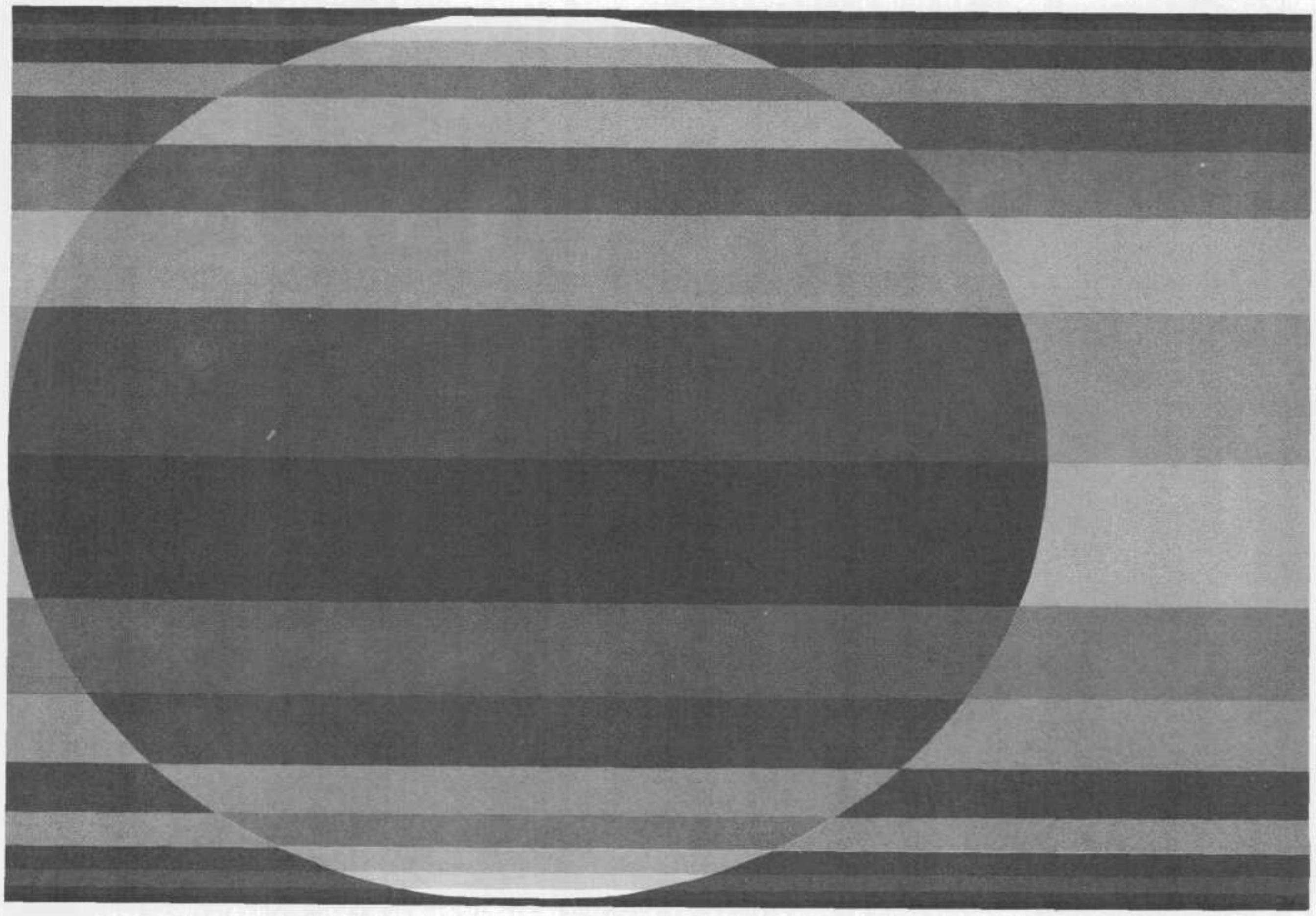
BACKGROUND PAPER

Counterforce Issues for the U.S. Strategic Nuclear Forces

January 1978



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COUNTERFORCE ISSUES FOR THE
U.S. STRATEGIC NUCLEAR FORCES

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Congressional Budget Office

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PREFACE

In recent years, concern has grown that one element of the TRIAD of U.S. strategic nuclear forces, land-based ICBMs, might become vulnerable to a first strike by an improving Soviet ICBM force. The fiscal year 1979 budget will present to the Congress several programs that respond to this growing threat. This background paper, prepared at the request of the Senate Budget Committee, discusses the significance of the Soviet counterforce threat against Minuteman and the arguments for and against the development of a similar U.S. capability. Together with the forthcoming companion paper on retaliatory issues, it supports a forthcoming Budget Issue Paper for fiscal year 1979 on strategic nuclear forces.

This paper was prepared by Robert R. Soule of the National Security and International Affairs Division of the Congressional Budget Office, under the supervision of John E. Koehler. The author wishes to acknowledge the assistance of Virginia G. France, David R. Martin, John Shewmaker, Carl R. Neu, Linda S. Moll, Nancy J. Swope, and Patricia J. Minton. Cost estimates were provided by Edward Swoboda of the Budget Analysis Division of the Congressional Budget Office. Editorial assistance was provided by Patricia Johnston. In accordance with CBO's mandate to provide objective analysis, this paper offers no recommendations.

Alice M. Rivlin
Director

January 1978

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SUMMARY

U.S. strategic nuclear forces consist of three parts: land-based intercontinental ballistic missiles (ICBMs), long-range bombers, and submarine-launched ballistic missiles (SLBMs). Together these three parts are known as the TRIAD.

These forces are an important part of perceived U.S. military power, and as such serve a variety of political and military functions; chief among these functions is that of deterring a Soviet nuclear attack. To deter such an attack, U.S. forces must be capable of surviving a Soviet nuclear attack against them (usually referred to as a "counterforce" attack) in sufficient numbers to threaten retaliation that would be unacceptable to the Soviet Union.

In recent years, concern has grown that one element of the U.S. TRIAD, land-based ICBMs, might become vulnerable to a first strike by a Soviet ICBM force consisting of increasingly accurate missiles armed with Multiple Independently Targetable Reentry Vehicles (MIRVs). Although current and programmed U.S. forces will continue to provide a capability to destroy Soviet urban industrial centers in a second strike, additional nuclear weapons might be required for deterrence of a Soviet counterforce strike, since a U.S. threat to destroy Soviet cities might not be credible as long as U.S. cities remained intact and the Soviet Union retained forces capable of destroying them. Some analysts argue that unless U.S. strategic forces were capable of retaliating against the Soviet ICBMs remaining after a first strike against the United States, the Soviet Union might be able to gain an advantage by destroying the U.S. land-based missile force.

The need for several programs to modernize and augment U.S. strategic forces will depend upon judgments made about the desirability of developing a second-strike counterforce capability. These judgments will affect decisions about such weapon programs as the following:

- Development and procurement of the MX missile, a more powerful, more accurate, and potentially mobile ICBM;

- Development and procurement of the Trident II missile, a more powerful, more accurate submarine-launched missile;

- The ultimate size of the Trident submarine fleet and the pace of submarine construction; and

- The number of bomber-launched cruise missiles and cruise missile carriers.

U.S. Strategic Vulnerability

A successful counterforce attack on land-based ICBMs in hardened underground silos would require a force of MIRVed missiles with high accuracy and warhead yield. Many observers have expressed concern that the large-scale deployment of the new generation of MIRVed Soviet ICBMs (the four-warhead SS-17, the eight-warhead SS-18, and the six-warhead SS-19) may pose a significant threat to the U.S. ICBM force. This modernization program will apparently not be significantly constrained by a SALT II agreement.

The 6,000 to 7,000 independently targetable warheads that may eventually be in the Soviet ICBM arsenal would not, however, all be useful in a simultaneous attack on U.S. land-based missiles. An important attack constraint results from the effects of nuclear detonations on warheads entering an area where previous explosions have taken place, a phenomenon known as fratricide. This phenomenon would probably limit an attacker to one or two explosions per target. As a result, the current generation of Soviet MIRVed ICBMs, if their accuracy proves to be no better than 1,500 to 1,200 feet, could probably destroy no more than about 40 to 60 percent of the U.S. land-based missile force. Furthermore, even damage of this magnitude would be a risky prospect for an attacker, since a great deal of uncertainty surrounds estimates of missile reliability and accuracy, warhead yield, and silo resistance to nuclear effects. These uncertainties together raise the possibility that a Soviet counterforce attack would leave many more U.S. missiles surviving than anticipated.

If the Soviets are to enhance their counterforce capability, they must improve the accuracy of their missiles. Reports have indicated that the Soviets have yet another generation of ICBMs under development, presumably being designed for improved accuracy. Preventing the development and deployment of more accurate, multiple-warhead Soviet ICBMs will be an important task for future arms limitation negotiations. If new missiles capable of accuracies of about 600 feet were developed and deployed, then by the mid-to-late 1980s, over 90 percent of the U.S. ICBM force might be vulnerable to a Soviet attack that allocated two warheads to each silo. A Soviet leadership could not, however, count on damage of this magnitude, since there would be a 5 percent chance that

only 75 percent would be destroyed, leaving 250 U.S. ICBMs remaining after a counterforce attack rather than 100.

In any case, ICBMs are only one part of the U.S. nuclear arsenal. In fact, about half of the equivalent megatonnage in the U.S. force, a measure of area destructive power, is carried by long-range bombers, while half of the warheads, a measure of the ability to attack large numbers of targets, are carried by submarine-launched ballistic missiles. Since alert bombers and submarines at sea will probably maintain their survivability and their ability to penetrate enemy air defenses into the foreseeable future, even a successful Soviet attack on U.S. ICBMs would not compromise the ability of the United States to inflict devastating retaliation on the Soviet Union.

U.S. Counterforce Capability

The threat to retaliate against Soviet cities might not deter a Soviet counterforce attack, since the United States would be reluctant to attack Soviet cities as long as U.S. cities remained intact and the Soviet Union maintained reserve forces capable of destroying them. For this reason, the United States might desire an ability to carry out a counterattack against Soviet ICBMs to deter a Soviet counterforce strike. If U.S. forces that survived a Soviet first strike were capable of destroying most of the Soviet ICBMs held in reserve, then no possible gain would result from a Soviet attack, and deterrence might be enhanced.

There are several objections to any U.S. attempt to buy forces designed to fight counterforce wars. First, even with the complete loss of the ICBM force, the United States would still have enough weapons for counterattacks on Soviet conventional military targets or isolated economic assets, in addition to those needed for attacks on Soviet cities.

Most importantly, a U.S. second-strike counterforce capability might be indistinguishable to the Soviet Union from a first-strike force. Because of their relatively greater dependence on ICBMs, the Soviets might be particularly sensitive to a U.S. counterforce threat. As a result, a Soviet leadership facing a serious international crisis might feel strong incentives to launch a preemptive strike against U.S. strategic forces before their own land-based missiles could be destroyed.

A threat to the Soviet ICBM force might compel the Soviet Union to build new weapons to compensate for the vulnerability of their silo-based missiles. Thus, a new round of U.S. arms produc-

tion might reduce, rather than enhance, U.S. security. Proponents of a U.S. counterforce capability suggest that the Soviet arms buildup is already threatening strategic stability and that a threat to the survivability of Soviet ICBMs would force the Soviet Union either to negotiate an agreement limiting the counterforce threat or to reduce their reliance on silo-based missiles and shift to a more survivable basing system. In either case, the survivability of land-based missiles would be enhanced and incentives to strike first would be reduced.

If a second-strike counterforce capability were desired, the United States would require additional and more sophisticated weapons. Silo-based weapons, such as the existing Minuteman force, are becoming increasingly vulnerable to attack, and, in any case, could not destroy more than about 40 to 60 percent of the Soviet ICBM force even in a first strike. Even a U.S. weapon as formidable as the MX missile, if based in vulnerable Minuteman silos, would lose its ability to counterattack effectively against Soviet reserve ICBMs as the Soviets improve the accuracy and counterforce capability of their own forces. Moreover, silo-based deployment of a weapon as theatening as the MX missile would destabilize the nuclear balance, since in a crisis the Soviets might have a strong incentive to try to knock out a U.S. force that could destroy over 90 percent of Soviet ICBMs if the United States were allowed to shoot first.

Mobile weapons would be able to survive a Soviet first strike against them and could therefore be effective in a second strike. Mobile counterforce weapons include MX missiles that could move at random in ten- to twelve-mile long underground trenches or among several protective above-ground shelters, Trident II submarine-launched missiles, and bomber-launched cruise missiles. These weapons have different implications for strategic stability than do silo-based forces. Since Soviet forces could probably not destroy them in a preemptive attack, the Soviet Union would have less incentive to launch a first strike. Thus, crisis stability might not be jeopardized by deployment of mobile-based U.S. counterforce weapons.

Arms control might be complicated by the introduction of a mobile-based counterforce weapon such as MX. Such a weapon would be more difficult to count than silo-based missiles, and thus enforcement of arms control agreements might be more difficult. Proponents of U.S. counterforce capability have argued that even mobile weapons could be counted at "choke-points" through which all deployed missiles would have to pass, such as the entrances to underground tunnels. Moreover, they argue that a U.S. missile system threatening to Soviet silo-based ICBMs would probably force the Soviet Union to move to a mobile missile-basing system of

their own, thus reestablishing a stable situation in which it would not pay for either side to attack the forces of the other. Opponents of weapon systems such as MX suggest that it would be better to avoid such an expensive solution to the ICBM vulnerability problem by reaching arms control agreements that limit the counterforce threat. For example, strict limits on missile flight tests or on the number of ICBMs that could be armed with multiple warheads might prevent both sides from developing an ability to attack each other's land-based missiles. There is disagreement, however, over whether or not the prospect of MX deployment would contribute to the negotiation of such an agreement, since many believe that ongoing U.S. arms programs provide bargaining leverage, while others argue that U.S. restraint would better contribute to the negotiating process.

It might be better to develop a new mobile ICBM only to improve survivability and not to enhance U.S. counterforce capability. Such a course would seek to avoid the potentially destabilizing aspects of counterforce capability, yet it would respond to the growing vulnerability of silo-based ICBMs. Counterforce proponents argue that the counterforce potential of the MX missile would be desirable since the United States might want to be able to retaliate against Soviet ICBMs remaining after an attack on vulnerable U.S. forces, such as silo-based missiles and nonalert bombers and in-port submarines.

One way to develop a U.S. second-strike counterforce capability without posing a first-strike threat to the Soviet Union might be to rely on accurate cruise missiles to counterattack against Soviet ICBMs. Since these weapons would take several hours to reach their targets, they would probably not be seen as first-strike weapons. Because of their accuracy, cruise missiles would be very effective against hardened Soviet ICBM silos. There may, however, be a possibility of developing air defenses against cruise missiles, although the Department of Defense believes that U.S. cruise missile technology will stay ahead of Soviet defensive technology. Furthermore, there remains some uncertainty about cruise missile accuracy and reliability since this weapon is still in development.

U.S. Options

Finite Deterrence. A policy of finite deterrence would rely upon a well-hedged threat to retaliate against Soviet cities to deter nuclear attacks by the Soviet Union, including strikes against U.S. strategic forces. In practice, the United States

would have enough weapons for other forms of retaliation, such as attacks on Soviet conventional military targets. Under a policy of finite deterrence, the United States could procure Trident I missiles, about 20 Trident submarines, and about 3,000 cruise missiles for the B-52 force. New counterforce weapons such as MX ICBMs, Trident II SLBMs, and large numbers of bomber-launched cruise missiles would not be required under this policy. A force for finite deterrence would cost about $111.2 billion (in fiscal year 1978 dollars) for investment and operating from fiscal years 1979 to 2000.

Slow Counterforce. Under a policy of slow counterforce, the United States would add to its base force of Trident submarines and missiles, B-52 bombers, and Minuteman ICBMs enough cruise missiles and cruise missile carriers for a counterattack against Soviet ICBMs. Because bombers would take several hours to reach the Soviet Union, such a force would provide an ability to carry out a second-strike counterforce attack without posing a first-strike threat to Soviet land-based strategic forces. During the period between fiscal years 1979 and 2000, a policy of slow counterforce would add $14.3 billion (in fiscal year 1978 dollars) to the base force cost of $111.2 billion, for a total cost of $125.5 billion.

Prompt Counterforce. A policy of prompt counterforce would call for the procurement of mobile MX ICBMs and/or Trident II SLBMs. These weapons would provide a capability to retaliate against Soviet ICBMs within minutes of a Soviet first strike. Procurement of the MX missile system could also enhance the survivability of the land-based force and thus maintain a viable TRIAD. Such a policy would reflect a judgment that a mobile missile system threatening to the Soviet ICBM force would be stabilizing rather than destabilizing, because mobile missiles would be invulnerable to a Soviet preemptive strike and because they would provide a means to respond to, and thus deter, a Soviet counterforce attack.

During the period between fiscal years 1979 and 2000, procurement of the MX system would add $25.2 billion (in fiscal year 1978 dollars) to the costs of the strategic forces, for a total cost of $136.4 billion. A sea-based counterforce capability would require the procurement of 768 Trident II missiles and 12 extra Trident submarines at a cost of $28.7 billion (in fiscal year 1978 dollars), for a total cost of $139.9 billion.

The following table summarizes the costs of the three options.

SUMMARY OF COSTS OF THREE OPTIONS: BY FISCAL YEARS

	(In Millions of Current Dollars) 1979	1980	1981	1982	1983	(In Millions of FY 1978 Dollars) 1979 through 2000
Finite Deterrence	7,120	8,530	9,110	9,600	10,210	111,200
Slow Counterforce	7,120	8,530	9,110	9,600	10,210	125,500
Prompt Counterforce						
MX Option	7,330	9,130	10,340	11,430	11,910	136,400
Trident II Option	7,230	8,410	9,750	11,790	13,020	139,900

NOTE: Costs shown do not include all the costs of maintaining the strategic forces. Not included are the costs of such functions as command, control, and communications; surveillance; and strategic defense; and the costs of nuclear warheads.

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CHAPTER I. INTRODUCTION

U.S. strategic nuclear forces are charged with the mission of deterring a Soviet nuclear attack on the United States. 1/ Since defenses against a nuclear attack are both difficult and limited by the Anti-Ballistic Missile Treaty between the United States and the Soviet Union, the United States relies upon the ability of its strategic forces to carry out a devastating retaliatory strike against Soviet cities to deter a Soviet attack. U.S. forces are designed to be capable of carrying out this "assured destruction" mission after having absorbed a well-coordinated surprise Soviet strike against them.

In order to hedge against the failure or destruction of one part of its nuclear force, the United States maintains a mixed force of long-range bombers, land-based intercontinental ballistic missiles (ICBMs), and submarine-launched ballistic missiles (SLBMs), known collectively as the TRIAD. By diversifying the force among three parts, each of which has different vulnerabilities, a Soviet nuclear attack on U.S. strategic forces, usually referred to as a "counterforce" attack, is made more difficult.

In recent years, however, concern has grown that one element of the U.S. strategic TRIAD, land-based ICBMs, may become vulnerable to a disarming first strike by an increasingly capable Soviet force. Using a fraction of their ICBM force, the postulated Soviet attack would destroy large portions of U.S. missiles in their hardened silos. Simultaneous attacks on U.S. Strategic Air Command (SAC) bases and submarine ports would destroy bombers not on alert and missile-carrying nuclear submarines (SSBNs) not at sea. At the same time, the existence of a large Soviet reserve force capable of destroying U.S. cities would deter a U.S. counterstrike against Soviet cities and thus leave U.S. leaders with few attractive retaliatory options.

1/ In principle the strategic nuclear forces are also designed to deter attacks by other countries, but for the foreseeable future the need to deter attack by other countries will not significantly increase U.S. force requirements.

Considerable controversy has surrounded both the issue of U.S. vulnerability to a Soviet counterforce attack and the question of what the Soviets might hope to gain from such an attack. Many observers believe that the United States faces a significant, and growing, Soviet counterforce threat and that a deterrence doctrine that relies upon retaliation against Soviet cities would provide American leaders with few credible responses to such an attack. They believe that to deter a Soviet counterforce attack U.S. strategic forces must be able to carry out a counterattack against the Soviet ICBM force, since the threat to retaliate against Soviet cities might not be credible as long as U.S. cities remain intact.

On the other side are critics of any U.S. attempt to plan and build forces for counterforce wars, those confined to each side's nuclear forces. These critics believe that a Soviet nuclear attack confined to strikes against U.S. strategic forces would inflict so much damage on U.S. cities and population that the United States would be expected to respond with its surviving SLBMs and alert bombers and that this expectation should deter any but the most desperate Soviet leadership from attempting such a strike. Furthermore, many believe that U.S. preparations to fight counterforce battles only make nuclear war more likely to occur because U.S. weapons capable of counterattacking against Soviet ICBMs might appear to pose a first-strike threat to Soviet strategic forces and thus cause a Soviet leadership facing a serious international crisis to launch a preemptive attack.

Over the next several years the Congress will face a number of important force procurement issues that depend critically on judgments about the degree and signficance of U.S. strategic vulnerability to Soviet counterforce capability and the proper response to such a development. By the mid-1980s, when U.S. silo-based missiles will probably become increasingly vulnerable to Soviet attack, Trident nuclear submarines and Trident I submarine-launched missiles will be entering the force, and cruise missiles will be deployed on B-52 bombers. Although these systems will probably be sufficient for retaliation against Soviet industry, leadership targets, and general purpose military forces, 2/ many analysts have expressed concern about the pos-

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2/ For an examination of the second-strike capabilities of U.S. forces against Soviet industry and general purpose military forces, see the forthcoming companion paper on retaliatory issues.

sibility that improved Soviet ICBMs will enable the Soviet Union to launch a counterforce strike against U.S. silo-based ICBMs, while the United States could not respond in kind. If the Congress wishes to maintain strategic forces capable of carrying out a second-strike counterforce attack against Soviet ICBMs, the procurement of new and more sophisticated weapons would be required.

Judgments about the significance of Soviet counterforce capability and the need for a similar U.S. capability will, to a great extent, determine the pace of development and magnitude of procurement of MX mobile missiles, Trident submarines, Trident II missiles, cruise missiles, and cruise missile carriers beyond the existing B-52 force.

The MX missile, a more accurate, more powerful, and potentially mobile ICBM now in the research and development (R&D) stage and available for deployment by the mid-1980s, will provide a future option to reduce the vulnerability of land-based missiles, and at the same time substantially upgrade the counterforce potential of the U.S. nuclear arsenal.

The large missile tubes of the Trident submarines now under construction will be capable of housing a larger and more accurate Trident II missile. This missile, which could be developed by the mid-to-late 1980s, offers an alternative means of developing a capability to attack Soviet ICBM silos in a second strike. Since the assignment of submarine-launched missiles to the counterforce role would, however, require the procurement of additional submarines beyond those needed for retaliation against Soviet cities, the present Trident building rate of three submarines every two years would have to be accelerated in the near future.

The U.S. cruise missile, guided to its target by a terrain-matching guidance system that is asserted to be extremely accurate, will provide another means to enhance the counterforce capability of U.S. strategic forces. If the Congress decides to procure extra cruise missiles for the counterforce task, additional carriers, such as wide-bodied aircraft, would be required.

Decisions about these programs to augment and modernize U.S. strategic nuclear forces in the mid-to-late 1980s will depend upon several basic questions:

- Under what circumstances might the Soviets be tempted to strike one vulnerable element of the U.S. TRIAD, knowing that a large retaliatory force would survive?

- o Should the United States develop the capability to retaliate against Soviet ICBMs?

- o Is the best response to increasing ICBM vulnerability a shift to more survivable basing systems or the development of a similar threat to Soviet ICBMs?

- o How might the Soviet Union react to a threat to their ICBMs, and would this reaction be desirable or undesirable?

Chapter III of this study examines the projected vulnerability of U.S. strategic forces, especially the ICBM portion of those forces. Chapter IV deals with the arguments for and against the development of U.S. counterforce capability.

Before examining the issues of U.S. strategic vulnerability and counterforce capability, however, it is useful to consider the question of Soviet motives in launching a counterforce attack. Only in this context is it possible to develop general criteria for judging the success or failure of a given Soviet strategy and what may be required to deter it.

CHAPTER II. COUNTERFORCE STRATEGIES

In any discussion of counterforce exchanges it should always be remembered that a major nuclear war would be a catastrophe of unprecedented proportions; starting or risking such a war would be a desperate act undertaken only under great stress and in the face of a perceived threat to very important values. Even a war confined strictly to attacks on nuclear forces would likely cause millions of deaths and great damage and disruption on both sides. In addition, neither side could be certain that a limited nuclear exchange would remain limited and not eventually escalate to all-out attacks that would cause the deaths of tens of millions. In fact, it is difficult to imagine the circumstances in which initiating a nuclear war would be the least miserable option facing national leaders. Precisely because a nuclear war would be such a catastrophe, however, prudence demands that the factors that might contribute to its occurrence be carefully considered.

In general, there are at least three Soviet counterforce strategies that have been postulated. They are:

- o An attack on the U.S. ICBM force designed to reduce U.S. options in a limited nuclear war.
- o An attack on U.S. strategic forces designed to shift decisively the balance of nuclear power in favor of the Soviet Union.
- o An attack on U.S. strategic forces designed to limit damage to the Soviet Union in an all-out nuclear war.

In recent years the Department of Defense (DoD) has concentrated on the first of these strategies, expressing concern that a successful Soviet counterforce strike against land-based missiles would endanger the ability of the United States to execute flexible options short of all-out retaliation. The superior accuracy and command and control capability inherent in a land-based system, capabilities that might be important for strikes against Soviet military forces involved in a war in Europe or other

areas of U.S. treaty commitments, would be lost in such an event. 1/ Leaving aside the controversy surrounding the issue of limited nuclear options and the desirability of maintaining forces designed for such contingencies, there are several questions that can be raised about the scenario postulated by the Defense Department.

For one thing, it is unclear that the United States would remain interested in the execution of flexible and controlled responses after having absorbed a large-scale nuclear attack on U.S. ICBMs that killed millions of Americans. In any case, given the existence of thousands of nuclear weapons in surviving ICBMs, bombers, and submarines, as well as tactical missiles and aircraft, the United States would retain many retaliatory options, since surviving forces would be capable of carrying out strikes against Soviet conventional forces or important isolated economic targets. Many analysts believe, however, that U.S. forces should be capable of carrying out a counterattack against Soviet ICBM silos. A requirement that U.S. strategic forces be able to perform such a second-strike counterforce mission might call for the procurement of additional, and more sophisticated, U.S. nuclear weapons.

Others have suggested that the Soviet Union might be motivated to strike U.S. strategic forces in order to shift decisively the balance of power in their favor. A counterforce attack with this goal in mind would be designed to destroy such a large portion of U.S. forces with such a small expenditure of Soviet

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1/ Defense Secretary Schlesinger summarized this concern:

> Since both we and the Soviet Union are investing so much of our capability for flexible and controlled responses in our ICBM forces, these forces could become tempting targets, assuming that one or both sides acquire much more substantial hard-target kill capabilities than they currently possess. If one side could remove the other's capability for flexible and controlled responses, he might find ways of exercising coercion and extracting concessions without triggering the final holocaust.

(Annual Defense Department Report, FY 1976 and FY 197T, page II-4.)

force that the Soviets would gain strategic superiority so massive that the extreme asymmetry in the destruction that the two sides could inflict on one another would deter the United States from using its inferior force in retaliation. In this case, American leaders might be left with few response options, and U.S. forces might fail to deter a Soviet first strike. To deter a Soviet counterforce attack designed to shift the balance of nuclear power, many analysts believe that the United States must maintain survivable forces large enough to prevent a massive Soviet advantage in the ability to inflict damage. Others believe that the U.S. forces should be capable of counterattacking against Soviet strategic forces remaining after a counterforce strike against the United States. In this way, the United States might be able to redress an imbalance of power resulting from a Soviet first strike.

A third possible Soviet counterforce strategy would involve attacks on U.S. nuclear forces for the purpose of limiting the damage that the United States could inflict on the Soviet Union in an all-out nuclear war. Obviously, a Soviet leadership considering such an attack would have to be convinced that circumstances were so desperate that nuclear war was imminent. In this case, by striking first, the Soviets might be able to destroy a large percentage of the U.S. nuclear force, thus making the outcome of a nuclear war less catastrophic for the Soviet Union than it otherwise would have been. Deterrence of a damage-limiting strike requires that U.S. nuclear forces must be able to survive a Soviet counterforce attack against them and then carry out a devastating retaliatory attack against Soviet cities. U.S. forces capable of retaliating against Soviet nuclear forces would not be required in this case. The survivability of U.S. forces is examined in Chapter III of this study.

Those who believe that the Soviet Union might be tempted to attack U.S. strategic forces for the purpose of reducing American options or shifting the balance of power suggest that deterrence requires not only forces capable of destroying Soviet cities but also weapons designed to counterattack against Soviet nuclear forces. Opponents of such a second-strike counterforce policy suggest that there is a dilemma involved in the procurement of U.S. counterforce weapons. They believe that a U.S. force large enough to retaliate against Soviet nuclear forces in a second strike would, by definition, pose a significant first-strike threat to the Soviet Union. Furthermore, this threat might dangerously destabilize the strategic balance and provide an incentive for a Soviet first strike. Chapter IV focuses on the question of U.S. second-strike counterforce capability and the associated doctrine.

U.S. ICBM VULNERABILITY

In the 1960s, silo-based Intercontinental Ballistic Missiles (ICBMs) were thought to be essentially invulnerable to a first strike. In order to destroy such a target, an attacker would have to fire a missile of his own at each enemy missile site. Since many of the attacker's missiles would fail to function properly or miss their targets, it was inevitable that the attacker would use more weapons than he could possibly destroy. Thus, given roughly equal forces, an attack under such circumstances would be a self-disarming act.

In recent years, however, technological advances have dramatically altered this picture. The crucial event was the development of Multiple Independently Targetable Reentry Vehicles, or MIRVs. With missiles that carry more than one warhead, an attacker can potentially destroy more than one enemy missile for each one he uses. If the U.S. and Soviet ICBM forces were constrained to be of roughly equal size, either by arms control agreements or by cost considerations, then an attacker using MIRVed missiles might be able to destroy a large part of the other side's ICBMs while expending only a fraction of his own force.

The United States developed and deployed the first MIRVed ICBM, the three-warhead Minuteman III missile. In 1975 the Soviet Union began deployment of its own MIRVed ICBMs, the SS-17, SS-18, and SS-19. This coupling of traditionally large Soviet missiles with MIRV technology has been a particularly disquieting event, because the power of these missiles makes possible the delivery of large numbers of warheads. The SS-18, for example, can deliver eight to ten warheads, thus creating the possibility that each SS-18 might destroy several U.S. silo-based missiles.

Even with the deployment of MIRVed missiles, the actual vulnerability of ICBM silos to a counterforce strike is determined by the interaction of several other factors: the hardness of the target; the accuracy, explosive power, and reliability of the attacking missile; and the tactics used in the attack. For example, a one megaton warhead, typical of Soviet weapons, delivered

by a reliable missile with circular error probable (CEP) 1/ of 1,200 feet (0.2 nm) would have less than a 50 percent chance of destroying a silo hardened to withstand 2,000 pounds per square inch (psi). If accuracy could be improved to 600 feet (0.1 nm), the same one megaton weapon would have almost a 90 percent chance of destroying the same target. A missile accurate to 600 feet but with warhead yield of only 20 kilotons (equivalent to the bomb dropped on Hiroshima), however, would have less than a 20 percent chance of destroying a target hardened to 2,000 pounds per square inch. Thus, an appropriate combination of accuracy and warhead yield is needed for an effective counterforce capability.

U.S. missiles are generally believed to be more accurate than their Soviet counterparts, but in recent years the Soviet Union has been making great strides in the field of guidance technology. Since the warhead yields of the current generation of Soviet ICBMs are already very large, improvements in missile accuracy will be the major driving force behind growing Soviet counterforce capability.

Uncertainties of Attack Effectiveness

A very significant consideration for attack planning is the great uncertainty surrounding the actual accuracy of any given guidance technology. This uncertainty results in part from the limited number of tests a missile system undergoes to verify its accuracy potential. Gaining high confidence in estimates of a missile CEP would require a large number of tests for each missile and for each change in its guidance system. Such testing is constrained, however, by the limited resources that can be devoted to the very expensive task of missile testing. Moreover, actual operational performance can be degraded by variable atmospheric conditions and small perturbations in the earth's gravitational

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1/ The measure most commonly used to describe the accuracy of a ballistic missile is known as circular error probable (CEP). This is the radius, centered about the intended target, that forms a circle within which 50 percent of the warheads will land.

field. 2/ As a result, actual CEPs can only be estimated within a fairly large range of uncertainty, and any assessment of the damage that an attack can be expected to cause must take into account the uncertainties surrounding these operational accuracies.

Although missile accuracy is perhaps the most important source of uncertainty about the actual results of a counterforce attack, similar uncertainty surrounds estimates of warhead yield, missile and warhead reliability, and silo hardness. Again, much of this uncertainty results from the limited amount of test data. In addition to the expense of missile and warhead tests, other constraints prevent the gathering of complete knowledge about the performance of weapon systems. For example, treaty restrictions on atmospheric detonations prevent actual testing of silo hardness. As a result, no one can know for sure how resistant these shelters will be to the various effects of nuclear detonations.

Fratricide and Counterforce Tactics

The operational performance of weapons is not the only source of uncertainty about the results of a counterforce attack. In recent years analysts have come to recognize an additional attack constraint resulting from the effects of nuclear detonations on warheads entering an area where previous explosions have taken place. This phenomenon, known as "fratricide," could cause the destruction of weapons used in a large-scale attack on missile fields, and it therefore places severe restrictions on counterforce tactics that involve the targeting of more than one warhead on each silo. In fact, most analysts believe that no more than two warheads could be exploded in the neighborhood of each enemy

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2/ American missiles are typically fired over the Pacific Ocean at Kwajalein Island in the Marshall Islands. While such tests may give weapons designers precise knowledge of the gravitational forces that this portion of the earth exerts on ballistic missile flight, they are not necessarily accurate indicators of how a missile fired over the Arctic at the Soviet Union would perform. Presumably the Soviet Union faces similar uncertainty about possible accuracy degradation because of unpredictable guidance errors of this sort. As a consequence, an attacker could never be sure that his missiles would perform in an actual counterforce attack as test data would lead him to believe.

missile silo. Even a two-on-one attack would be difficult, since first-wave warheads would have to be exploded several hundred feet above the target in order to avoid throwing lethal ground debris into the air, while second-wave warheads (targeted to explode on the ground) would have to enter the area with split-second timing in order to avoid destruction by the nuclear effects of first-wave warhead detonations.

It is possible that no more than one warhead could be successfully exploded over each target. Other nuclear effects, such as intense heat and dust clouds, could be lethal to subsequent warheads even if first-round weapons were burst above the surface in order to avoid the throwing of ground debris into the air. 3/ An attacker who accepted this view would fire two warheads (both programmed to detonate on ground contact) at each enemy silo only to insure against the possibility that the first one proved to be unreliable and either failed to reach the area of the target or to explode. 4/ If no more than one nuclear warhead could be exploded in the neighborhood of each target, an attacker would be better off not to try for two detonations, since such an attempt requires that less accurate, less destructive airbursts be used in the attack. 5/

3/ For an unclassified discussion of fratricide, see Joseph J. McGlinchey and Jakob W. Seelig, "Why ICBMs Can Survive A Nuclear Attack," Air Force Magazine, September 1974.

4/ More than two warheads could be fired at each silo, but the small additional probability that at least one warhead would reach each target would probably not be worth the cost in terms of expended attacker weapons.

5/ The penalty for an unsuccessful attempt to explode two warheads over each silo can be quantified by examining the case in which fratricide proves to be unavoidable and first-wave airburst warheads destroy second-wave groundburst warheads. Expected damage to the ICBM force in this case would be 44 percent for an attack with SS-18 missiles accurate to 1,200 feet (assuming 20 percent height of burst error for airburst warheads, and assuming that second-wave groundburst warheads reach 25 percent of the silos due to first-wave failures). This 44 percent damage expectancy compares with 54 percent for the case of two groundbursts (one explosion). The potential loss of 10 percent damage expectancy compares with a potential gain of 8 percent if an attempt to explode two warheads over each silo were successful (see Appendix B).

Uncertainties about fratricide will probably never be settled. For one thing the prohibition on atmospheric testing prevents real world evaluation of a modern warhead's ability to withstand the various effects of a nuclear explosion. In light of the penalties that would be paid for an unsuccessful attempt to avoid fratricide, an attacker would probably have to make the conservative assumption that insuring against missile and warhead unreliability is the best tactic available. On the other hand, consideration of more ambitious attacks that successfully detonate two warheads in the area of each target does serve to provide an upper bound for the damage that a Soviet counterforce strike might cause. 6/

A third counterforce tactic attempts to program two warheads to detonate in the neighborhood of each target while at the same time reprogramming spare missiles to replace those that fail in the early portions of flight. In a two-on-one attack that attempts to explode two warheads in the area of each target, reprogramming for reliability would be a particularly demanding task, since the warheads from replacement missiles would have to arrive on target at the same time as those of the failed missiles in order to avoid fratricide. For this reason, an attack that could get two successful explosions in the neighborhood of each target and reprogram failed missiles is probably the worst scenario that U.S. missiles could possibly face.

U.S. ICBM Vulnerability in the Mid-1980s

As we have seen, a successful counterforce attack requires a force of MIRVed ICBMs that combines high accuracy and warhead yield. Until recently, the Soviet Union did not possess such a force. The bulk of the Soviet ICBM force consisted of single-warhead SS-9s and SS-11s that are reportedly capable of accuracies no better than about one to one-half of a nautical mile. 7/

6/ More than two warheads might be exploded in the area of each silo if the attacker waited for an hour or more for dust clouds to dissipate. A delay of this length would, however, greatly increase the opportunity for the victim to launch his surviving missiles.

7/ See Thomas J. Downey, "How to Avoid Monad and Disaster," Foreign Policy, Fall 1976.

By the mid-1980s, the Soviets should complete deployment of a new generation of MIRVed ICBMs, the SS-17, SS-18, and SS-19 with four, eight, and six warheads respectively. This modernization program will apparently not be significantly constrained by a SALT II treaty, since the Soviets will probably be allowed to replace all their large SS-9 ICBMs with MIRVed SS-18 missiles and since very high limits on MIRVed ICBMs will be allowed. 8/ One unclassified estimate of what Soviet strategic forces might look like by 1985 is presented in Table 1. For comparison, estimates of the size and structure of U.S. forces are presented in Table 2 for both 1977 and the mid-1980s.

Many observers have expressed concern that a Soviet ICBM force consisting of thousands of multiple warheads, with the combination of high yield and improved accuracy shown in Table 1, would pose a significant threat to the U.S. ICBM force. With the aid of computer missile exchange simulations based on the estimates presented in Tables 1 and 2, it is possible to examine in more detail the exact nature of this threat. 9/

An attacker planning a counterforce strike would have an incentive to program both warheads fired at each enemy missile silo to detonate on ground contact. Although such a tactic would probably eliminate any chance to get two detonations in the neighborhood of each target, it would greatly increase the odds that every enemy silo would suffer the effects of a nuclear explosion, and it would avoid the use of less accurate, less destructive airbursts. A Soviet attack that exploded no more than one warhead on each target (but fired two), using 264 eight-warhead SS-18s, all accurate to 1,500 feet, against 1,054 U.S. ICBM silos, 10/ would be expected to destroy about 40 percent

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8/ See "Major Concessions By U.S. and Soviet on Arms Reported," New York Times, October 11, 1977, p. 1.

9/ The SNAPPER Force Exchange Model developed for the Air Force by the Rand Corporation has been used to calculate attack results. For a detailed description of this model see Appendix A.

10/ Assuming Minuteman silo hardness of 2,000 pounds per square inch and Titan hardness of 550 pounds per square inch. See "MX Deployment Urged for Parity," Aviation Week and Space Technology, December 5, 1977, p. 13.

of the land-based missile force. This would leave intact 60 percent of the U.S. ICBM force, consisting of over 600 missiles, 1,200 warheads, and 600 equivalent megatons. 11/ Even if Soviet missile accuracies could be improved to 1,200 feet, only about 55 percent of U.S. ICBMs would probably be destroyed, leaving 45 percent of the land-based force, or over 450 missiles, 950 warheads, and 450 equivalent megatons. 12/

These results indicate the number of U.S. missiles that can be expected to survive a Soviet attack, given specific assumptions about the performance of the weapon systems involved in the attack. As discussed in previous sections, a great deal of uncertainty surrounds estimates of these parameters. Therefore, an attacker would have to consider the degree of confidence that he could have in the results of an attack, as well as the best guess about those results. If the values of CEP, warhead yield, reliability, and target hardness are all allowed to vary within reasonable limits, the range of results that would bound the actual, unknown result with 90 percent confidence can be determined. For an attacker concerned about the catastrophic consequences of failure, a reasonably narrow confidence interval would obviously be an important consideration in the decision to attack or not. In the attacks described above, the number of surviving U.S. ICBMs can vary, with 90 percent confidence, from 70 percent to 45 percent after an attack by Soviet missiles theoretically capable of 1,500-foot accuracies. In other words, there is a 5 percent chance that 70 percent of the U.S. ICBMs, rather than 60 percent, would survive the Soviet attack, and a 5 percent

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11/ Equivalent megatonnage is a commonly used measure of the urban area destructive power of a nuclear weapon that accounts for the fact that area destructive power does not increase proportionately with increases in yield. It is expressed by the relationship EMT = N multiplied by Y to the 2/3 power, where N is the number of weapons of yield Y.

12/ If the Soviets could succeed in exploding two warheads over each silo, they could destroy about 50 percent of the U.S. ICBM force, assuming a 1,500 ft. Soviet CEP. A Soviet two-on-one attack with missiles accurate to 1,200 feet would be expected to destroy about 60 percent of U.S. ICBMs. If two warheads could be exploded over each U.S. silo and early missile failures could be reprogrammed, damage to the U.S. ICBM force would be expected to be 55 percent, assuming a 1,500 ft. Soviet CEP, or slightly less than 70 percent, assuming 1,200 ft. CEP. For detailed results, see Appendix B.

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TABLE 1. ESTIMATED SOVIET STRATEGIC NUCLEAR FORCES, 1985

Launcher	Number a/	Warheads Per Launcher b/	Total Warheads	Yield in Megatons c/	Total Megatons	Equivalent Megatons	Reliability d/	Circular Error Probable e/
SS-11	330	1	330	1.5	495	432	0.70	3,000 ft.
SS-17	200	4	800	0.6	480	560	0.75	1,500 ft.
SS-18	308	8	2,464	1.5	3,696	3,228	0.75	to
SS-19	500	6	3,000	0.8	2,400	2,580	0.75	1,200 ft.
SS-16	60	1	60	1.0	60	60	0.75	
Total ICBMs	1,398		6,654		7,131	6,860		
SS-N-6 / SS-N-8	600	1	600	1.0	600	600	0.70	6,000 ft.
SS-N-17 / SS-N-18	300	3	900	0.2	180	306	0.70	3,000 ft.
Total SLBMs	900		1,500		780	906		
Bear	100	1	100	20	2,000	740		
Bison	40	1	40	5	200	116		
(Backfire)	(250)	(2)	(500)	(0.2)	(100)	(170)		
Total Bombers	140 (390)		140 (640)		2,200 (2,300)	856 (1,026)		
Grand Total	2,438 (2,688)		8,294 (8,794)		10,111 (10,211)	8,622 (8,792)		

(continued)

TABLE 1. (Continued)

SOURCES:

a. Number of SS-18s and total number of SS-17s and SS-19s from testimony of General Alton Slay, in Military Posture and H.R. 11500, Hearings before the House Armed Services Committee, 94:2 (1976), Part 5, p. 288. Ratio of SS-19s to SS-17s assumed same as at present. Number of MIRVed SLBMs assumes 1,320 MIRVed ballistic missile limit. Numbers of Bears and Bison from General George S. Brown, United States Military Posture for FY 1978, p. 18. Number of Backfire assumes annual production of 25 (see International Institute for Strategic Studies (IISS), The Military Balance, 1977-78 (London: 1977), p. 4.).

Total number of Soviet delivery vehicles shown exceeds any likely SALT II agreement. Given a limit of 2,200 strategic delivery vehicles, the Soviets would have to retire about 200 launchers, probably older SS-11 ICBMs and Bear and Bison bombers. With a MIRVed ICBM ceiling of 800, 200 fewer SS-17s and SS-19s would probably be deployed. SS-18 deployment would not necessarily be affected.

b. Number of ICBM warheads from Donald H. Rumsfeld, Annual Defense Department Report, Fiscal Year 1978, p. 62. SLBM warhead figures from General George S. Brown, United States Military Posture for FY 1978, p. 16. Bomber figures from Projected Strategic Offensive Weapons Inventories of the U.S. and U.S.S.R., Congressional Research Service, March 24, 1977, p. 85.

c. Warhead yields from "MX Deployment Urged for Parity," Aviation Week and Space Technology, December 5, 1977, pp. 14-15, and Jane's Weapon Systems, 1977, pp. 10-12. Bomb yields from Projected Strategic Offensive Weapons Inventories of the U.S. and USSR, p. 95.

d. Obtaining missile reliability greater than 80 percent is believed to be a very difficult task (see Albert C. Hall, "The Case for an Improved ICBM," Astronautics and Aeronautics, February 1977, p. 29). Soviet missiles are generally considered to be less reliable than their U.S. counterparts.

e. Although official estimates of Soviet missile accuracies are classified, various public sources provide an unclassified consensus estimate of 1,500 ft. (0.25 nm) CEP for the new generation of Soviet ICBMs. See "U.S. Missiles Seen Vulnerable by Early 1980s," Washington Post, September 18, 1977, p. A6. In addition, one official statement adds credence to this estimate. In an appearance before the Senate Foreign Relations Committee in 1974, Secretary of Defense James Schlesinger testified: "We have some information that the Soviets have achieved, or will soon achieve, accuracies of 500 to 700 meters with their ICBMs. These figures may be a little optimistic, but that would represent about a fourth to a third of a nautical mile." (Briefing on Counterforce Attacks, Hearing before the Subcommittee on Arms Control, International Organizations and Security Agreements of the Senate Foreign Relations Committee, 94:1 (September 11, 1974), p. 10.) In addition, defense officials have alluded to the possibility of further improvements in accuracy with continued testing of the current generation of missiles. (See Department of Defense Authorization, Fiscal Year 1978, Hearings before the Senate Armed Services Committee, 95:1 (April 1977), Part 10, p. 6869.) Therefore, accuracy upgrade to 1,200 ft. (0.2 nm) is also considered. See "MX Deployment Urged for Parity," Aviation Week and Space Technology, December 5, 1977, pp. 14-15.

TABLE 2. ESTIMATED U.S. STRATEGIC NUCLEAR FORCES

				(Present Force)				
Launcher	Number	Warheads per Launcher	Total Warheads	Yield in Megatons	Total Megatons	Equivalent Megatons	Reliability	Circular Error Probable
Minuteman II	450	1	450	1.0	450.0	450	0.80	1,800 ft.
Minuteman III	550	3	1,650	0.17	280.5	512	0.80	700 ft.
Titan II	54	1	54	9.0	486.0	232	0.75	3,000 ft.
Total ICBMs	1,054		2,154		1,216.5	1,194		
Polaris	160	1	160	0.6	96	163	0.80	3,000 ft.
Poseidon	496	10	4,960	0.04	198	595	0.80	1,500 ft.
Total SLBMs	656		5,120		294	758		
B-52 G/H	255	4 SRAM	1,020	0.2	204	347		
		4 Bombs	1,020	1.0	1,020	1,020		
B-52D	75	4 Bombs	300	1.0	300	300		
FB-111	60	2 SRAM	120	0.2	24	41		
		2 Bombs	120	1.0	120	120		
Total Bombers	390		2,580		1,668	1,828		
Grand Total	2,100		9,854		3,178.5	3,780		

SOURCES: There is fairly wide agreement among various unclassified estimates of U.S. nuclear forces. For ICBM and SLBM figures, see Thomas J. Downey, "How to Avoid Monad and Disaster," Foreign Policy, Fall 1976; Statement of the Honorable Robert L. Leggett, Vladivostok Accord: Implications to U.S. Security, Arms Control, and World Peace, Hearings before the Subcommittee on International Security of the House Committee on International Relations, 94:1 (June-July 1975), pp. 8-14; and Kosta Tsipis, "The Accuracy of Strategic Missiles," Scientific American, July 1975, p. 190. Minuteman III CEP of 700 ft. (see "U.S. Plans 'Cold-Launch' ICBMs," Aviation Week and Space Technology, February 4, 1974, p. 14) assumes the more accurate MK-12A warhead not yet deployed. For bomber estimates, see Archie L. Wood, "Modernizing the Strategic Bomber Force Without Really Trying--A Case Against the B-1," International Security, Fall 1976, and Alton H. Quanbeck and Archie L. Wood, Modernizing the Strategic Bomber Force (The Brookings Institution, 1976), p. 36.

(continued)

TABLE 2. (Continued)

				(Mid-1980s Force)				
Launcher	Number	Warheads per Launcher	Total Warheads	Yield in Megatons	Total Megatons	Equivalent Megatons	Reliability	Circular Error Probable
Minuteman II	450	1	450	1.0	450.0	450	0.80	1,800 ft.
Minuteman III	550	3	1,650	0.17	280.5	512	0.80	700 ft.
(with MK-12A)	(550)	(3)	(1,650)	(0.35)	(572.5)	(825)	(0.80)	(600 ft.)
Titan II	54	1	54	9.0	486.0	232	0.75	3,000 ft.
Total ICBMs	1,054		2,154		1,216.5 (1,508.5)	1,194 (1,507)		
Poseidon	336	10	3,360	0.04	134	403	0.80	1,500 ft.
Poseidon C-4	160	8	1,280	0.10	128	282	0.80	1,500 ft.
Trident I	240	8	1,920	0.10	192	422	0.80	1,500 ft.
Total SLBMs	736		6,560		454	1,107		
B-52 G/H	165	6 SRAM	990	0.2	198	337		
		4 Bombs	660	1.0	660	660		
B-52CM	165	20 ALCM	3,300	0.2	660	1,122		300 ft.
FB-111	60	2 SRAM	120	0.2	24	41		
		2 Bombs	120	1.0	120	120		
Total Bombers	390		5,190		1,662	2,280		
Grand Total	2,180		13,904		3,332.5 (3,629.5)	4,581 (4,894)		

SOURCES: MK-12A yield from "Cruise Missile Halt Considered," Aviation Week and Space Technology, May 23, 1977, p. 19. Lower Minuteman III CEP assumes that MK-12A warhead is more accurate than older MK-12 warhead. Trident I missile estimates from "New Propellant Evaluated for Trident Second Stage," Aviation Week and Space Technology, October 13, 1975, p. 15. Cruise missile yield from "ICBM, Guidance Curbs Alarm Planners," Aviation Week and Space Technology, July 11, 1977, p. 17. Cruise Missile CEP from Kosta Tsipis, "Cruise Missiles," Scientific American, February 1977, p. 29. Cruise missiles assumed carried by 75 B-52Ds and 90 B-52Gs.

chance that only 45 percent would survive. If Soviet missiles were theoretically accurate to 1,200 feet, there would be a 5 percent chance that 60 percent of the U.S. ICBM force, rather than 45 percent, would survive, and a 5 percent chance that only 30 percent would survive. 13/

Unless the Soviet Union can make dramatic improvements in its missile accuracies, it would appear that the generation of MIRVed ICBMs now being deployed could not deliver a decisive blow to the U.S. Minuteman force. Even if missile accuracy could be improved to 1,200 feet, the Soviets could probably destroy no more than 40 to 60 percent of the U.S. ICBM force. In addition, damage of this magnitude would be a risky prospect, since the operational performance of weapon systems is subject to many uncertainties.

U.S. ICBM Vulnerability in the Mid-to-Late-1980s

It has been reported that the Soviet Union is developing four new ICBMs. 14/ These missiles are apparently in the pre-flight phase of development and should be ready for deployment by the mid-1980s. 15/ Former Chief of Naval Operations, Elmo R. Zumwalt, has reported that component testing of these missiles has been observed. 16/ This would place their development at about the same stage as that of the U.S. MX missile.

Although little information about the characteristics of these new missiles is available in the public record, it is believed that improved accuracy is a primary Soviet goal. Therefore, as an approximation of the future threat to U.S. land-based missiles, it is useful to examine the case of a Soviet attack

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13/ See Appendix B for attack outcome variations.

14/ See speech of Secretary of Defense Harold Brown before the National Security Industrial Association, reported in "Brown Sees Buildup by Soviets in Missiles," New York Times, September 16, 1977, p. 9.

15/ Department of Defense Authorization, Fiscal Year 1978, Hearings before the Senate Armed Services Commitee, 95:1 (1977), Part 10, pp. 6859-60.

16/ Elmo R. Zumwalt, "An Assessment of the Bomber-Cruise Missile Controversy," International Security, Summer 1977.

using a missile similar in payload and yield to the SS-18 but capable of accuracies of 900 to 600 feet (0.15 to 0.10 nm). 17/

With accuracies as good as those assumed for the next generation of Soviet missiles, the ability to avoid fratricide and explode two warheads in the area of each target becomes insignificant since single detonations would produce high damage probabilities. With extremely accurate missiles, second warheads would need to be fired only to improve the odds that each enemy missile silo would come under attack by at least one weapon. For example, a Soviet attack using missiles accurate to 600 feet that programs two groundbursts (one explosion) per target in order to insure against missile and warhead unreliability would be expected to destroy over 90 percent of the U.S. ICBM force, leaving a land-based force of less than 100 missiles, 200 warheads, and 100 equivalent megatons. 18/

Although an attack that plans for only one explosion per target is a much less risky tactic, unpredictable variations in the performance of weapon systems can still result in a range of attack outcomes. In fact, for the case of an attack with missiles theoretically capable of accuracies of 600 feet, the range of outcomes can vary, with 90 percent confidence, from 25 percent to 5 percent surviving U.S. ICBMs. Thus, the Soviet leadership would have to consider the prospect that there would be a 5 percent chance that 250, rather than 100, U.S. ICBMs would be available for retaliation.

In short, while an attempt at a disarming strike against silo-based ICBMs would be clearly a risky and unprofitable strategy with missiles accurate only to 1,200 feet or more, an attack with weapons accurate to 600 feet or less might be able to destroy over 90 percent of the land-based U.S. strategic deterrent. Even this latter case is risky, however, because of the range of uncertainty in the outcomes. In addition, land-based ICBMs are only one element of the TRIAD, and important retaliatory capabilities would survive in the bomber and submarine forces even after a highly successful attack on ICBMs. In order to assess

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17/ Defense Department officials have stated that the achievement of "extreme" accuracies must await the next generation of Soviet ICBMs. See Senate Armed Services Committee, Department of Defense Authorization, Fiscal Year 1978, Part 10, pp. 6860, 6866-67.

18/ For detailed results, see Appendix C.

the profitability of a successful counterforce strike against U.S. ICBMs, it is necessary to examine the vulnerability of the other two elements of the U.S. TRIAD, submarine-based missiles and long-range bombers.

U.S. BOMBER VULNERABILITY

Since the United States maintains about half of its equivalent megatonnage in its bomber force, a damage-limiting strike by the Soviet Union that held out any hope of success would have to include attacks on U.S. B-52 and FB-111 bombers. An attacker seeking to minimize the destruction that this force could inflict would have two separate opportunities to stop U.S. bombers. First, surprise attacks on Strategic Air Command (SAC) bases might destroy bombers at or near their bases. Second, air defenses might try to inflict significant attrition on aircraft before they could use their weapons.

Prelaunch Vulnerability

There is no doubt that most bombers not on alert at the time of an SLBM or ICBM attack on their bases could be destroyed. Although only 30 percent of the U.S. B-52 force is maintained on ground alert under normal peacetime conditions, in time of crisis crews could be recalled to their bases and the vast majority of the force placed on alert. A surprise attack on non-alert bombers is often used, however, as a conservative assumption in assessing bomber survivability.

Bombers on alert would be more difficult targets, but many observers believe there is reason for concern about the survivability of this portion of the force as well. These observers believe that it might be possible for Soviet submarines to fire their missiles from positions close to U.S. shores, thereby destroying a large part of the alert bombers at or near their bases. Although the survivability of alert bombers is a very important concern, there are several reasons to question this scenario.

Most importantly, planning a coordinated attack on U.S. bomber bases would present an adversary with difficult, perhaps insurmountable, problems. First, in order to minimize missile flight time, and thus warning time, Soviet submarines would have to station themselves close to U.S. coasts. Such a move would probably be detected by U.S. antisubmarine warfare (ASW) sensors, thus providing the United States with warning of an attack. Since detection of provocative Soviet submarine deployments would enable

the United States to put the entire bomber force on alert, an attempt to launch a surprise attack on alert bombers could be a counterproductive tactic. Furthermore, since a damage-limiting strike would probably be considered by the Soviet Union only in a time of extreme crisis, U.S. forces would almost certainly be in a high state of readiness at the time of an attack.

Even if U.S. bombers were not in their highest state of readiness, and even if Soviet submarines could position themselves for attack without being detected, there are reasons to doubt that alert aircraft could be destroyed at their bases. Given a bomber reaction time of about three to six minutes, 19/ alert aircraft would have more than enough time to escape attacks on their bases by SLBMs with flight times of ten to fifteen minutes. 20/ Missiles flying on fast, depressed trajectories would take about seven minutes to reach bomber bases, 21/ providing a slim margin of safety for alert bombers. There is no evidence, however, that the Soviets have tested SLBMs flown on depressed trajectories. 22/ If such tests were to be carried out at some future date, there would be greater cause for concern about the prelaunch survivability of alert bombers, and several corrective measures to insure the survivability of the bomber force might be called for. These measures include the dispersal of bombers to a larger number of bases in the interior of the continental United States and the maintenance of higher alert rates and a more rapid reaction status for alert aircraft.

19/ See Alton H. Quanbeck and Archie L. Wood, Modernizing the Strategic Bomber Force (The Brookings Institution, 1976), pp. 46-47; and Francis P. Hoeber, Slow to Take Offense: Bombers, Cruise Missiles, and Prudent Deterrence (Center for Strategic and International Studies, Georgetown University, February 1977), pp. 84-85.

20/ Statement of James R. Schlesinger in Briefing on Counterforce Attacks, Hearings before the Subcommittee on Arms Control, International Organizations and Security Agreements of the Senate Committee on Foreign Relations, 94:1 (September 11, 1974), p. 22.

21/ Quanbeck and Wood, op. cit., p. 44.

22/ Donald H. Rumsfeld, Annual Defense Department Report, Fiscal Year 1978, p. 123.

Penetration Survivability

Even after bombers have successfully escaped attacks on their bases, they still face threats to their ability to carry out their retaliatory mission. The Soviet Union has deployed an extensive network of air defenses consisting of about 6,500 surveillance radars, 2,540 interceptors, and 10,000 surface-to-air missile (SAM) launchers. 23/ Furthermore, it is projected that these defenses will be further strengthened with the eventual development of an advanced Soviet air defense system against low-flying aircraft.

There would be several ways to degrade these defenses in a nuclear war between the United States and the Soviet Union. First, surviving U.S. land- and submarine-based missiles might be used to destroy a large portion of Soviet air defenses before the arrival of the bomber force. 24/ Second, surviving air defenses could be attacked by the nuclear-armed Short Range Attack Missiles (SRAMs) carried by penetrating bombers. Furthermore, even without these potent nuclear countermeasures, the record of U.S. electronic countermeasures (ECM) used by Americans in Vietnam and Israelis in the 1973 Middle East war indicates that these measures can be extremely effective against Soviet air defense systems. 25/ Finally, in the future the U.S. bomber force will include thousands of long-range cruise missiles whose low-level flight and small size will help them avoid detection and whose large numbers should be capable of saturating surviving Soviet defenses.

THE SUBMARINE-BASED FORCE

Ballistic missile-launching nuclear-powered submarines (SSBNs) comprise the third element of the U.S. strategic TRIAD. Because these submarines carry about half of the warheads in the U.S arsenal, a measure of the ability to attack large numbers of targets, their destruction would be an especially important requirement for a successful Soviet damage-limiting strike.

23/ Ibid., p. 58.

24/ See James R. Schlesinger, Annual Defense Department Report, FY 1976 and FY 197T, p. II-20.

25/ Quanbeck and Wood (op. cit.) cite estimates of 3 percent U.S. attrition in the 1972 bombing raids against North Vietnam and 1 to 1.5 percent Israeli attrition in the 1973 war. See pp. 64-65.

At the present time, U.S. nuclear-powered submarines at sea are considered essentially invulnerable to Soviet attack. This belief is based on several factors. First, U.S. submarines are considered to be extremely quiet, providing little, if any, chance for Soviet acoustic sensors to detect them in the open ocean. Second, Soviet antisubmarine warfare capabilities are not considered particularly sophisticated. Finally, geography is a distinct disadvantage for the Soviets because they have very limited access to the open oceans where most U.S. submarines are expected to operate.

Not only is it likely that current U.S. strategic submarines will remain highly survivable into the foreseeable future, but Trident submarines now under construction will be even quieter than current submarines and will be equipped with the most sophisticated passive sonar equipment available. In fact, Navy officials have stated that the combination of quieting improvements and advanced sonar equipment will allow Trident submarines to detect enemy forces before they are themselves detected. 26/ As a result, Soviet antisubmarine warfare forces would have great difficulty detecting and destroying U.S. submarines.

The key to any effort to attack submarines at sea is large-area ocean surveillance. The Soviets have no such system today. To hedge against the development of such a system, possibly satellite-based, the 4,000 nm. range of the new Trident I missile planned for deployment on Trident submarines as well as ten Poseidon boats will dramatically expand the ocean area available for on-station patrol. Moreover, the large Trident submarine tubes allow for the possibility of a 6,000 nm. range Trident II missile. Such an expansion of patrol area greatly magnifies the tasks faced by an enemy seeking to track and destroy a large number of submarines that are trying to avoid detection.

Trident I will not only double the range of the older Poseidon missile, but reportedly it will also increase the destructive power carried by each missile from an average of ten 40-kiloton warheads to eight 100-kiloton warheads (see Table 2). It has also been reported that the Trident II missile, if de-

26/ Department of Defense Authorization, Fiscal Year 1977, Hearings before the Senate Armed Services Committee, 94:2 (1976), Part 12, pp. 6548-49.

ployed, could carry 14 150-kiloton warheads or seven MK-12A 350-kiloton warheads. 27/

One area of potential submarine vulnerability that does concern the Navy involves the methods used to receive communications. At the present time, submarines use an antenna close to or above the surface of the ocean for this purpose. As a result, a Soviet satellite system that could detect these antennas might pose a threat to the survivability of all or part of the submarine force. For this reason, the Navy has proposed construction of an Extremely Low Frequency (ELF) communications system, called Seafarer, that would allow receipt of messages without the necessity of bringing either the submarine or its antenna close to the surface where it is most vulnerable. Therefore, if a threat to submarine concealment should develop, serious consideration should be given to construction of an ELF-like communication system.

While submarines at sea are now very survivable and will likely remain so into the foreseeable future, submarines in port remain highly vulnerable. The Trident submarine offers the promise of future improvement in this area as well. About 55 percent of the Polaris and Poseidon submarine force is maintained at sea during peacetime. 28/ Although Defense Department officials have stated that this percentage can be raised to almost 99 percent of submarines not in overhaul during a crisis, 29/ or about 80 percent of the total submarine force, this leaves a large part of the U.S. sea-based deterrent vulnerable to a surprise attack. With such advances as a longer life reactor core and improved logistics facilities, however, Trident submarines are expected to maintain a peacetime at-sea rate of 66 percent. 30/ This represents an increase in potential survivability of 20 percent and is equivalent to the deployment of additional submarines and missiles.

27/ See "New Propellant Evaluated for Trident Second Stage," Aviation Week and Space Technology, October 13, 1975, pp. 16-17.

28/ Senate Armed Services Committee, Department of Defense Authorization, Fiscal Year 1978, Part 10, p. 6621.

29/ Ibid., p. 6624.

30/ Ibid., p. 6621.

In sum, the U.S. submarine force, which carries approximately half of all the warheads in the U.S. strategic nuclear arsenal, appears to be the most survivable part of the TRIAD. Programs now underway or options available in the future should maintain this survivability into the foreseeable future.

THE VULNERABILITY OF THE TRIAD

Although it is useful to examine the vulnerability of the three elements of the strategic TRIAD individually, it is the size of all surviving U.S. forces that determines whether a dangerous vulnerability to a Soviet first strike exists. It is likely that an adversary interested in a counterforce strike against the United States would attack all three forces together. To do otherwise would only increase the damage that surviving American forces could inflict in a nuclear war.

To attack all three elements of the U.S. strategic TRIAD together, however, would introduce new complications for the attacker, since each part might contribute to the survivability of another. For example, simultaneous attacks on bomber bases and ICBM fields might provide the irrefutable evidence of nuclear war necessary for a decision to launch ICBMs on warning, a possibility that would have to give a potential attacker cause for concern. Furthermore, detection of preparations for an attack, such as the positioning of a large number of missile-carrying submarines close to American shores or unusual activity in enemy ICBM fields, might allow the United States to put a much larger percentage of its own forces on peak alert, thereby increasing their survivability. Because of these interactions, certain ambitious enemy attacks, such as a surprise attack on <u>alert</u> bombers, would probably be especially risky undertakings.

U.S. Vulnerability in the Mid-1980s

The worst case faced by the United States through the early 1980s would be a comprehensive surprise attack on U.S. nuclear forces in their day-to-day alert posture. Although it is difficult to find a motive for an unprovoked surprise attack, this scenario does provide a lower bound for the number of U.S. surviving forces. In such an attack, Soviet submarine-launched missiles would be targeted against U.S. bomber bases, and 70 percent of the B-52 force would be destroyed. Attacks on U.S. submarine ports would be expected to destroy the 45 percent of the Poseidon fleet and the 34 percent of the Trident force not at sea. The U.S. ICBM force would come under attack by some 260 SS-18

missiles, each carrying eight 1.5 megaton warheads accurate to perhaps 1,200 feet. After such a surprise attack, the United States would probably be left with about 6,400 warheads and 1,800 equivalent megatons. (The Soviets would have a reserve force consisting of about 6,000 warheads and 6,000 equivalent megatons.)

Since 1,000 Poseidon SLBM warheads could destroy about 75 percent of the Soviet industrial targets (Trident warheads will be even more destructive), and since the same number of cruise missiles could destroy over 80 percent of the Soviet industrial base, the United States would have more than enough weapons in both the bomber and submarine parts of the TRIAD to destroy the Soviet Union as a modern industrial society. 31/ Thus, given the survivability of at-sea submarines and alert bombers, a Soviet counterforce attack on U.S. ICBM silos, submarine ports, and bomber bases does not offer the prospect of successful damage-limiting. In addition, since the United States would have more weapons than those required for attacks on Soviet cities, other U.S. retaliatory options, such as attacks on Soviet military targets, would be available after a Soviet first strike. Moreover, the United States could maintain its nuclear force over an extended period of time, since most of the surviving U.S. weapons would be in submarines, which can remain at sea and effective for weeks or months.

If it is assumed that a nuclear war would not start with a totally unprovoked surprise attack, but rather after a period of rising tensions, then U.S. forces would be in a high state of readiness, often referred to as a generated alert posture, at the time of the attack. In this case at least 80 percent of the bomber force 32/ and 75 to 85 percent of the submarine-based force 33/ would survive a counterforce attack, leaving the United States with significantly more warheads and equivalent megatons than in the surprise attack scenario. An attack on U.S. forces in a generated alert posture would leave the United States with a

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31/ For an examination of the retaliatory damage that U.S. forces could do, see the forthcoming companion paper on retaliatory issues.

32/ Military Posture and H.R. 11500, Hearings before the House Armed Services Committee, 94:2 (1976), Part 5, p. 264.

33/ Senate Armed Services Committee, Department of Defense Authorization, Fiscal Year 1978, Part 10, p. 6621.

substantial force of over 10,000 warheads and 3,000 equivalent megatons.

U.S. Vulnerability in the Mid-to-Late 1980s

By the mid-to-late 1980s, the vulnerability of U.S. strategic forces may grow. In particular, if the Soviets develop and deploy an ICBM accurate to about 600 feet, the survivability of the Minuteman force could be seriously threatened. The shrinkage of the submarine force with the block retirement of the Poseidon fleet during this same period will also reduce the number of submarine-based missiles, although the increased payload and at-sea availability of the Trident force will somewhat offset this trend. If the Soviets were to attack U.S. forces in their day-to-day alert posture, and if about 90 percent of the ICBM force were destroyed, the United States would still have over 4,500 warheads and 1,400 equivalent megatons.

In the more likely case of a U.S. generated alert posture, the United States would have over 8,000 warheads and 2,700 equivalent megatons. The expected results of these Soviet counterforce strikes are summarized in Table 3. 34/

All the results presented above are expected value results based on specific assumptions about the operational performance of weapon systems in terms of accuracy, reliability, warhead yield, silo hardness, and the ability to avoid fratricide. Because a great deal of uncertainty surrounds estimates of these parameters, the Soviet leadership would have to consider the range of reasonable attack outcomes as well as point estimates. Given large variations in the number of U.S. ICBMs that would survive a Soviet attack against them, a counterforce strike would entail great risks. 35/

34/ Results for 1990 assume an ICBM force without the addition of MX or MK-12A warheads on Minuteman III missiles, an SLBM force based in five Poseidon submarines and 20 Trident boats (but without Trident II missiles), and a bomber force identical to that of the middle 1980s (see Table 2, second part).

35/ For details on attack outcome variations, see Appendices B and C.

TABLE 3. U.S. STRATEGIC FORCES SURVIVING A FIRST STRIKE

(Middle 1980s)

	Day-to-Day Alert			Generated Alert		
	Launchers	Warheads	Equivalent Megatons	Launchers	Warheads	Equivalent Megatons
ICBMs a/	466	968	479	466	968	479
SLBMs	440	3,904	667	560	4,992	842
Bombers	120	1,580	696	312	4,152	1,824
Total Survivors	1,026	6,452	1,842	1,338	10,112	3,145
(Percent)	(47)	(46)	(40)	(61)	(73)	(69)

(1990)

	Day-to-Day Alert			Generated Alert		
	Launchers	Warheads	Equivalent Megatons	Launchers	Warheads	Equivalent Megatons
ICBMs a/	93	193	96	93	193	96
SLBMs	360	2,880	634	472	3,776	831
Bombers	120	1,580	696	312	4,152	1,824
Total Survivors	573	4,653	1,426	877	8,121	2,751
(Percent)	(29)	(39)	(32)	(44)	(69)	(62)

a/ Number of surviving U.S. ICBMs assumes that Soviets fire two warheads, both programmed for groundburst, at each silo.

DETERRENCE AND STRATEGIC STABILITY

It is often suggested that the proper response to the growing Soviet counterforce threat is the development of a significant U.S. counterforce capability. The reasoning is that, even though U.S. forces surviving a Soviet first strike would probably be large enough to destroy Soviet cities, the United States would have few credible responses to a counterforce attack, since retaliation against Soviet cities would surely be returned in kind. Unless U.S. forces were capable of retaliation against the Soviet nuclear arsenal, the Soviet Union might be tempted to attack U.S. strategic forces, and especially the ICBM part of that force, in order to reduce U.S. options or shift the balance of strategic power against the United States. Such an attack might be particularly tempting if the United States had no way to respond in kind and if the Soviet leadership could convince themselves that U.S. leaders would never carry out the threat to destroy Soviet cities as long as U.S. cities remained intact. On the other hand, if a U.S. counterstrike against Soviet strategic forces could succeed in drawing down the Soviet arsenal to a level approximating that of the surviving U.S. force, then no advantage could be gained from a Soviet first strike against the United States. Thus, in an era of growing Soviet counterforce capability, deterrence may depend on U.S. acquisition of a second-strike counterforce capability. In recent years official Defense Department statements have hinted at a growing acceptance of such a second-strike counterforce doctrine.

> No opponent should think that he could fire at some of our Minuteman or SAC bases without being subjected to, at the very least, a response in kind. No opponent should believe that he could attack other U.S. targets of military or economic value without finding similar or appropriate targets in his own homeland under attack. No opponent should believe that he could blackmail our allies without risking his very capability for blackmail. 1/

1/ James R. Schlesinger, Annual Defense Department Report, FY 1976 and FY 197T, pp. II-4 and II-5.

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An even more direct statement of a second-strike counterforce doctrine was made in 1976 in hearings before the Senate Armed Services Committee:

> In attempting to retaliate for an attempted disarming first strike, one possibility, of course, is that of wiping out the Soviet Union. However, I think that a better way of responding is to wipe out what forces he holds back--his remaining blackmail capability--and, hence leave him in a position where he is worse off having executed the strike than not having executed it. If he is worse off doing it, he is not likely to do it. 2/

Several objections have been raised to the development of U.S. counterforce capability. Perhaps the most serious problem with U.S. forces designed for second-strike counterforce stems from the possibility that they would be seen as first-strike weapons, and thus be destabilizing. Two types of nuclear stability might be threatened by the development of U.S. counterforce capability: crisis stability and arms control stability. The first kind involves the incentives to strike first that each side would face in an international crisis. There may be an inescapable dilemma involved in the procurement of second-strike counterforce capability: a U.S. arsenal large enough to attack Soviet ICBMs after having absorbed a Soviet first strike would be large enough to threaten the Soviet ICBM force in a U.S. first strike. Moreover, the Soviet Union, looking at capabilities rather than intentions, might see a U.S. second-strike capability in this light. Faced with a threat to their ICBM force, Soviet leaders facing an international crisis might have an incentive to use their missiles in a preemptive strike before they could be destroyed by the United States. The Soviets might well be far more sensitive to a threat to the survivability of their ICBMs than the United States. The Soviets place far more emphasis on their ICBM force than does the United States, since the submarine and bomber segments of their nuclear arsenal are significantly less capable than those of the United States. Only 11 percent of

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2/ Statement of John B. Walsh, Deputy Director, Strategic and Space Systems, Office of the Director of Defense Research and Engineering, in Department of Defense Authorization, Fiscal Year 1977, Hearings before the Senate Armed Services Committee, 94:2 (1976), Part 11, p. 5930.

the Soviet submarine force is at sea at any one time, leaving the rest vulnerable to surprise attack. 3/ Furthermore, in light of the sophisticated nature of U.S. antisubmarine warfare capabilities and the fact that Soviet submarines are considered to be far noisier than their U.S. counterparts, even Soviet submarines at sea may be vulnerable, although longer-range Soviet SLBMs have reduced this vulnerability. In any event, the destructive power of at-sea Soviet SLBMs is limited because of the primitive nature of Soviet sea-based MIRV capability. Soviet bombers are also much smaller in number and in capability than their American counterparts (see Table 1).

Table 4 presents the expected outcome of three hypothetical U.S. first strikes against the Soviet ICBM force shown in Table 1. Several important implications can be drawn from these results. First, the counterforce capability of Minuteman III missiles against Soviet ICBMs seems to be comparable to the threat posed by the current generation of Soviet missiles to U.S. ICBMs; both sides would be able to destroy about 40 to 60 percent of the other's silo-based ICBMs. Specifically, 550 Minuteman III missiles with improved accuracy, each carrying three warheads, would be expected to destroy about 43 percent of the Soviet ICBM force. If the more accurate, more powerful MK-12A warhead were deployed on all 550 Minuteman III missiles, the United States could destroy about 64 percent of the Soviet land-based missile force in a first strike.

Second, the U.S. MX missile, with its reported ability to carry ten MK-12A warheads to within 400 feet of their targets, 4/ potentially could destroy about 92 percent of the Soviet Union's ICBMs, leaving about 100 missiles, 600 warheads, and 500 equivalent megatons in the Soviet land-based missile force. For comparison, only about 40 percent of Soviet ICBMs could be destroyed by a force of 550 Minuteman III missiles with improved accuracy. This result, when combined with consideration of the qualitative inferiority of the Soviet submarine force and the small size of the bomber force, indicates that deployment of a large number of MX missiles could pose a significant first-strike threat to the Soviet Union.

3/ General George S. Brown, United States Military Posture for FY 1978, p. 14.

4/ See "MX Deployment Urged for Parity," Aviation Week and Space Technology, December 5, 1977, p. 14.

TABLE 4. SOVIET ICBMs SURVIVING A U.S. FIRST STRIKE

U.S. Weapons Used in First Strike	Percent	Missiles	Warheads	Equivalent Megatons
550 Minuteman III	57	791	3,652	2,984
550 Minuteman III with MK-12A	36	508	2,542	2,124
300 MX	8	108	603	523

NOTE: Assumes U.S. programs two groundbursts per target if enough warheads are available. See Table 1 for pre-attack Soviet ICBM force. Soviet modernized silos assumed to be hardened to 2,000 pounds per square inch; 550 pounds per square inch for older SS-11s. MX assumed to carry ten 350-kiloton warheads with CEP of 400 feet and reliability of 0.85. See Table 2 for Minuteman III and MK-12A estimates.

Many opponents of U.S. counterforce capabilities believe that weapons threatening to the Soviet ICBM force would be extremely dangerous in a crisis. They argue that the Soviets would then have an incentive to strike first, since allowing the United States to fire first would result in the loss of a large portion of the Soviet force. Thus, paradoxically, a U.S. attempt to match Soviet counterforce potential might serve to increase, rather than reduce, the possibility of a Soviet attack. These critics also maintain that threats to the Soviet strategic deterrent would compel the Soviet Union to build new weapons to compensate for the vulnerability of their silo-based ICBMs. This Soviet reaction might bring with it not only renewed hostility, but also new weapons threatening to U.S. national security.

Others believe that improved U.S. counterforce capability is unnecessary. Even without the development of an expensive capability to destroy Soviet ICBMs, the United States would have several credible response options short of retaliation against Soviet cities in the event of a Soviet counterforce attack. One possibility would be to retaliate against Soviet conventional military forces. Alternatively, the United States could choose to attack other Soviet nuclear forces, such as submarine ports, bomber bases, and command and control facilities.

Leaving aside these philosophical issues of deterrence and stability, several questions about the effectiveness of second-strike counterforce weapons have been raised. As discussed above, such a counterforce capability has been justified as a means of enhancing deterrence of a Soviet nuclear attack by insuring that the Soviet Union could not gain an advantage by attacking U.S. strategic forces. Therefore, it is useful to examine the ability of present and proposed U.S. weapons to redress an imbalance of nuclear power (measured in terms of surviving ICBMs) created by a Soviet first strike, and thereby to deter such an attack. In doing so, U.S. weapons should be separated into those forces that are silo-based and those that are mobile-based. Silo-based weapons are examined first.

SILO-BASED COUNTERFORCE CAPABILITY

The United States has three possible candidates for silo-based counterforce weapons: the present force of 550 accuracy-improved Minuteman III missiles; a Minuteman III force upgraded by the addition of more accurate, higher-yield MK-12A warheads; and a force of more accurate, more powerful MX missiles in Minuteman silos.

The MX missile, now in the research and development stage and available for deployment by the middle 1980s, would be an especially formidable counterforce weapon. As mentioned earlier, the MX could reportedly carry ten MK-12A warheads to within 400 feet of their targets. Although now planned for deployment in either hardened underground trenches or above-ground shelters and justified as necessary for the destruction of a growing number of industrial and political targets in the Soviet Union, 5/ MX missiles in silos might be a timely and inexpensive means of developing a second-strike counterforce capability. The Minuteman III missile and an upgraded version incorporating the MK-12A warhead are described in Table 2.

If deployed in silos, all three of these U.S. weapons would face an increasingly challenging task in their second-strike counterforce roles as the Soviets continue to deploy their new generation of more accurate MIRVed ICBMs. This is so because improved Soviet counterforce capability decreases the number

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5/ See Senate Armed Services Committee, Department of Defense Authorization, Fiscal Year 1977, Part 11, p. 6520.

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of U.S. silo-based missiles that can be expected to survive a first strike, thus reducing the U.S. retaliatory force. Development and deployment of a new generation of Soviet ICBMs accurate to 600 feet would reduce even further the number of U.S. missiles expected to survive, making a second-strike attempt to redress the balance more difficult still. Table 5 shows the results of U.S.-Soviet counterforce duels both after the Soviet first strike and after the U.S. second strike.

With respect to the threat posed by full deployment of current generation Soviet ICBMs, the results in Table 5 indicate that in order successfully to redress an ICBM imbalance resulting from a Soviet first strike on silo-based missiles, the United States would need to deploy more powerful counterforce weapons than it currently possesses. In fact, even with deployment of higher-yield MK-12A warheads on all 550 Minuteman III missiles (not currently planned by the Defense Department), a first-strike imbalance could not be reversed. Deployment of 300 MX missiles in Minuteman silos, on the other hand, would enable the United States to "win" an ICBM exchange with a full force of the current generation of Soviet missiles. In this case, the United States would be expected to end up with 329 missiles compared with 211 surviving Soviet ICBMs.

The situation changes dramatically, however, if the Soviets deploy ICBMs accurate to 600 feet, an option that might be available to them by the time MX is ready for deployment in the mid-1980s. In this case the Soviet first strike would destroy such a large percentage of the U.S. ICBM force that a second strike by the surviving MX missiles would fall far short of redressing an imbalance. In fact, after such an exchange the Soviets would be expected to have 876 ICBMs compared with 79 U.S. land-based missiles. As a result, it appears that even the most powerful silo-based weapons might not be able to support a viable second-strike counterforce posture over the long run, unless the United States adopts a dangerous launch-on-warning posture.

Most importantly, powerful U.S. counterforce weapons, such as MX, if deployed in vulnerable missile silos, might be especially tempting targets for a Soviet leadership convinced that war with the United States was imminent. In this case the Soviets might strike first against U.S. ICBMs in order to protect their own nuclear deterrent, since to wait would risk the destruction of the Soviet land-based missile force. Thus, while it might be difficult to find rational motives for a Soviet first strike under present circumstances, the deployment of a weapon as threatening as the silo-based MX might supply one.

TABLE 5. TOTAL SURVIVING SOVIET AND U.S. ICBMs AFTER SOVIET FIRST STRIKE AND U.S. SECOND STRIKE

	U.S. ICBM Forces Involved in Counterforce Exchange		
	Force A a/	Force B b/	Force C c/
With 1,200 ft. Soviet CEP			
After Soviet First Strike			
Soviet	1,135	1,135	1,135
U.S.	466	466	466
After U.S. Second Strike			
Soviet	800	658	211
U.S.	215	215	329
With 600 ft. Soviet CEP			
After Soviet First Strike			
Soviet	1,135	1,135	1,135
U.S.	112	112	112
After U.S. Second Strike			
Soviet	1,069	1,032	876
U.S.	52	52	79

NOTE: Results assume that Soviet attack uses 264 SS-18s or SS-18 follow-ons, programming two groundbursts per U.S. silo to insure against missile and warhead failure. U.S. and Soviet modernized silos assumed to be 2,000 pounds per square inch; 550 pounds per square inch for older Titan II and SS-11 silos.

a/ 550 Minuteman IIIs, 450 Minuteman IIs, 54 Titan IIs. Only surviving Minuteman IIIs used in U.S. second strike.

b/ 550 Minuteman IIIs equipped with MK-12A warheads, 450 Minuteman IIs, 54 Titan IIs. Only surviving Minuteman IIIs used in U.S. second strike.

c/ 300 MXs, 250 Minuteman IIIs, 450 Minuteman IIs, 54 Titan IIs. Only surviving MXs used in U.S. second strike.

MOBILE-BASED COUNTERFORCE CAPABILITY

The United States has three options for the development of counterforce weapons in survivable mobile basing systems. These include: MX missiles in trenches or shelters, 6/ Trident II missiles in Trident submarines, and bomber-delivered weapons such as cruise missiles. These weapons have different implications for strategic stability than do silo-based forces.

MX Missiles

Although MX missiles in trenches or shelters would probably be as threatening to Soviet ICBMs as those in Minuteman silos, mobile-based missiles would be much less vulnerable to a Soviet attempt to destroy them. Current plans call for the deployment of each MX missile in concrete-encased trenches 10 to 12 miles long, buried beneath five feet of dirt. Since 300 missiles could move at random in over 3,600 miles of trench, an attacker would have to launch about 6,000 perfectly placed one-megaton warheads in an attempt to destroy all 300 mobile-based MXs. 7/ An attack of this magnitude would approach a self-disarming strike, and thus MX missiles in trenches would probably not be attacked. Moreover, improvements in Soviet missile accuracy would not threaten this survivability, since mobile U.S. missiles, unlike silo-based missiles, would be impossible to target. Two implications follow from this invulnerability. First, as second-strike weapons,

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6/ Basing in covered trenches is currently the preferred plan for MX deployment. If this concept proves to be impractical or too costly, shelter-basing would be used. In the latter system each MX missile would be moved at random from one protective above-ground shelter to another. Since the Soviet Union would not know which shelter the missile was in at any given time, all the shelters would have to be attacked to insure that the missile was destroyed.

7/ If trenches are hardened to 600 pounds per square inch (see "Strategic Force Options Related to SALT II," Congressional Research Service, Issue Brief IB77046, May 19, 1977, p. 7), each one megaton warhead could destroy slightly less than two-thirds of a nautical mile of trench. It should be noted, however, that trench hardness has yet to be determined. Lower hardness would require more miles of trench to guarantee the same survivability, thus increasing program cost.

trench- or shelter-based MX missiles would not be sensitive to improvements in accuracy or to changes in the number and size of warheads carried on Soviet ICBMs. As a result, unlike the case for silo-based weapons, a second-strike counterforce doctrine might be viable over the long run.

Second, crisis incentives would be different for mobile-based MXs. In this case, the Soviets would not be able to knock out the weapons that threaten their own ICBMs, and, therefore, little incentive to attack these weapons would exist. On the other hand, many argue that the Soviets would still have an incentive to use their weapons for something, such as attacks on vulnerable U.S. forces (for example, silo-based U.S. ICBMs, in-port submarines, or non-alert bombers) or even on U.S. cities, since to wait would risk their loss. Others argue that MX deployment would enhance, rather than undermine, crisis stability. Because MX missiles in trenches or shelters would be invulnerable, the Soviets would have few effective ways to use their weapons. If the Soviets used part of their ICBMs for attacks on other U.S. military targets, MX missiles could be used to destroy the rest of the Soviet ICBM force. Such an exchange would leave the Soviets worse off than before their attack. Attacks on U.S. cities would serve little purpose, since they would bring about U.S. retaliation against Soviet cities.

The implications of survivable counterforce weapons for arms control are also disputed. Many observers contend that mobile missiles such as the MX would mean the end of arms control agreements, since concealed weapons would be impossible to count. Others counter that mobile missiles might be counted at "chokepoints" through which all missiles would have to pass, such as the entrances to underground tunnels or to the missile fields themselves. In any case, it seems clear that the threat to the survivability of Soviet ICBMs posed by the MX would cause some Soviet reaction. Some analysts believe that a threat to Soviet ICBMs is an effective way to force the Soviet Union into mobile basing systems of their own, and that such a mobile ICBM program might divert Soviet resources away from weapon programs threatening to the United States. Mobile ICBM systems on both sides might also serve to reestablish a stable situation similar to the era of single-warhead missiles when an attacker could never destroy more of the enemy's missiles than he used in a first strike. The Department of Defense apparently sees the counterforce potential of the MX in this light.

> If the life of the fixed, hard ICBMs cannot be extended, then stability requires both sides to improve their land-based forces enough so that they are more diffi-

cult to target by the other side. The United States should not accept a strategic relationship in which we must bear the heavier costs of alternative basing while the Soviets are allowed the luxury of retaining their fixed ICBMs. Since high accuracies can be built into mobile as well as fixed systems, the Soviet leadership should be aware that if the United States moves toward mobility, the Soviets will have strong incentives to go mobile as well. 8/

Other analysts believe that the Soviet reaction to improved U.S. counterforce capability might not be so stabilizing. For example, the Soviet Union might adopt a dangerous launch-on-warning posture, or they might move to a system of mobile ICBMs that would be more difficult to count than the U.S. MX system. Some analysts speculate that the Soviets might develop new weapons capable of posing offsetting threats to the U.S. deterrent. They believe that U.S. national security interests would be better served by an arms control agreement that reduced the threat to silo-based ICBMs and eliminated the need for a mobile missile system as expensive as the MX. For example, improvements in Soviet missile accuracy and counterforce capability might be restricted by placing limits on the missile flight tests needed to develop new guidance systems. 9/ If verification of measures designed to restrict guidance improvements proved to be impractical, severe restrictions on large MIRVed Soviet ICBMs would be the only way to limit the threat to U.S. silo-based ICBMs. The Soviet Union has consistently resisted these sorts of restrictions, however. For this reason, proponents of U.S. counterforce weapons argue that the only way to force the Soviet Union into an agreement that limits the threat to U.S. ICBMs is to present that country with a threat to its own ICBM force, thereby supplying a powerful source of U.S. bargaining leverage. Because the Soviet Union is so dependent on its ICBM force, they might be especially interested in preventing U.S. deployment of a weapon as threatening as MX.

If the counterforce capability of the MX missile is judged to be on balance destabilizing, but a response to the growing vulner-

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8/ Donald A. Rumsfeld, Annual Defense Department Report, FY 1978, p. 72.

9/ Flight test restrictions would, of course, restrict the development of new U.S. missiles, such as the MX ICBM and the Trident II SLBM.

ability of silo-based ICBMs is desired, then a less threatening mobile ICBM might be developed to reestablish the survivability of the U.S. land-based missile force. Although the trench- or shelter-basing would constitute most of the cost of a mobile ICBM system, some money might be saved by reducing the capability of the missiles. Such a course would reflect a belief that the United States would not need a counterforce capability for retaliation against Soviet ICBMs remaining after an attack on vulnerable U.S. forces, such as older silo-based missiles and in-port submarines and non-alert bombers. U.S. restraint in the development of counterforce capability would also imply a judgment that it would be better to allow the Soviet Union to remain dependent on silo-based ICBMs rather than to threaten them and face the uncertainties surrounding predictions about the likely Soviet reaction to a threat to their land-based missile force.

Trident II Missiles

The Trident II missile, a larger and more accurate submarine-launched missile currently in the research and development stage, will provide an additional option to develop a U.S. counterforce capability in the mid-to-late 1980s. Because at-sea Trident submarines will probably be undetectable and thus invulnerable into the foreseeable future, a submarine-based counterforce capability would, like mobile MX missiles, be highly survivable and thus able to support a second-strike counterforce policy over the long run. Developing SLBMs capable of effective counterforce attacks may, however, be a challenging task, since it is very difficult to maintain extreme accuracy in a missile system based in submarines that do not have precise information on their position and velocity. External aids, such as Global Positioning System satellites that will be able to give precise information on position and velocity by the early 1980s, might be used to supplement Trident II's own inertial guidance. Dependence on external aids may, however, create new system vulnerabilities--in this case the possible vulnerability of the Global Positioning System satellites.

A sea-based counterforce capability would also require the procurement of additional Trident submarines beyond the twenty-some needed for attacks on cities, as well as the development and procurement of more sophisticated Trident II missiles to replace the smaller, less accurate first-generation Trident I missiles. With a force of 32 Trident submarines, armed with 768 more powerful Trident II missiles, the warheads carried by 12 submarines would provide enough weapons for the destruction of about 80 percent of Soviet industrial capacity and for a survivable strategic reserve. The remaining twenty submarines would provide

enough warheads for a two-on-one counterattack against the Soviet reserve ICBM force. Thus, the construction of about twelve extra Trident submarines and the development and procurement of the Trident II missile would be required for a U.S. sea-based counterforce capability.

Cruise Missiles

One way to get around some of the dilemmas involved in the deployment of second-strike counterforce weapons would be to use bombers in this role. Because bombers take several hours to reach their targets and can deliver nuclear weapons with great accuracy, they might provide a means to strike back against Soviet nuclear forces remaining after a first strike against the United States without posing a first-strike threat to the Soviet Union. In this role, the extreme accuracy promised by the terrain-matching guidance system of the cruise missile might be particularly useful. In fact, a two-on-one counterattack against reserve Soviet ICBMs by 2,800 cruise missiles accurate to 300 feet (see Table 2), would leave less than 150 surviving Soviet ICBMs, assuming cruise missile reliability and penetration probability of 85 percent each.

Some observers argue that, despite their accuracy, cruise missiles would be poor counterforce weapons. For one thing, these missiles are said to be vulnerable to low-altitude surface-to-air missiles that might be used to defend ICBM fields from counterattacks by cruise missiles, although Department of Defense officials have stated that U.S. cruise missile technology is expected to remain ahead of Soviet surface-to-air missile technology. 10/ Aircraft carrying cruise missiles might also be vulnerable to long-range, advanced Soviet interceptors--especially if SALT II restrictions on the range of cruise missiles force missile carriers to fly close to Soviet borders before launching their weapons.

In addition, many analysts argue that the long flight time of cruise missiles would allow the preemptive launch of Soviet ICBMs under attack. There are, however, reasons to question the utility of such a Soviet response. Since the Soviets would have already attacked the U.S. ICBM force, the number of targets available for a second-round Soviet strike would be limited. Attacks on U.S.

10/ See "Pentagon Aides Call Cruise Missile Able to Penetrate Soviet," New York Times, November 2, 1977, p. 6.

cities would serve little purpose, since the United States would then have little incentive to continue to refrain from retaliation against Soviet cities. Moreover, a Soviet leadership faced with the prospect that an attack on U.S. strategic forces would put their own ICBM force in jeopardy might be more reluctant to launch the initial attack. Thus, deterrence might be enhanced by the possibility that U.S. cruise missiles could carry out a second-strike counterforce attack.

Still others believe that there may be no way to circumvent the dilemmas posed by the acquisition of counterforce capability. They argue that the few extra hours needed by cruise missiles to reach their targets would make little difference to a Soviet leadership faced with the imminent destruction of their ICBM force and that the cruise missile might also look like a threatening first-strike weapon to the Soviet Union. In this view, it is the combination of the existence of stationary targets such as silo-based ICBMs and the development of extremely accurate new nuclear weapons that threatens to destabilize the nuclear balance. Because no stationary target can withstand the effects of a direct hit by a nuclear weapon, long-term nuclear stability may require that all strategic forces be based in mobile systems such as submarines, bombers, and mobile ICBMs.

CHAPTER V. U.S. OPTIONS

Possible U.S. responses to growing Soviet counterforce capability will depend upon judgments about the significance of this vulnerability, the amount and kind of hedging against Soviet threats desired, and the desirability of developing a U.S. counterforce capability. 1/

Three possible responses to the growing vulnerability of silo-based missiles are presented here: finite deterrence, slow counterforce, and prompt counterforce.

FINITE DETERRENCE

A policy of finite deterrence would be based on the belief that the Soviet Union would have little to gain from a counterforce attack against U.S. ICBMs and that the U.S. threat to destroy Soviet cities, even if the actual execution of the threat were uncertain, should be sufficient to deter any Soviet attack, including an attack confined to isolated military targets such as ICBM silos. In practice, even a finite deterrence force of about 20 Trident submarines, 300 B-52s armed with long-range cruise missiles, bombs, and short-range attack missiles, and the present force of 1,054 ICBMs would provide enough weapons for large-scale second-strike attacks on Soviet military targets, in addition to an ability to destroy the Soviet Union as a modern industrial society. Such a U.S. force would not, however, provide an effective capability to retaliate against Soviet ICBMs.

A policy of finite deterrence would reflect a judgment that U.S. counterforce weapons would undermine, rather than enhance, strategic stability. Critics of U.S. counterforce capability

1/ Strategic force requirements also depend upon judgments about the desired level and kind of retaliatory capability. For a discussion of these issues, see the forthcoming companion paper on retaliatory issues. For a more complete discussion of U.S. options and estimates of their cost, see the forthcoming CBO Budget Issue Paper for fiscal year 1979 on options for the 1980s.

argue that a threat to the survivability of the Soviet ICBM force, the most important part of the Soviet nuclear arsenal, would undermine crisis stability by providing an incentive for the Soviets to use their weapons before they could be destroyed. The development of U.S. counterforce capability might also complicate arms control efforts, since the Soviets would feel compelled to build additional, and possibly more dangerous, weapons to compensate for the vulnerability of their silo-based missiles.

The total number of ICBMs, submarine missiles, and bombers required for a policy of finite deterrence would be well under a SALT II limit of 2,200-2,400 delivery vehicles. On the other hand, a ceiling of 1,200 ballistic missiles that can be equipped with multiple warheads would require the retirement of about 80 Minuteman III ICBMs or Poseidon submarine missiles as MIRVed Trident I missiles are deployed with new Trident submarines. If B-52s or other aircraft armed with cruise missiles are counted under SALT II as MIRVed delivery vehicles, then the deployment of more than 120 cruise missile carriers will require further retirements.

A decision not to procure weapons capable of destroying Soviet silo-based ICBMs, such as MX ICBMs, Trident II SLBMs, and large numbers of bomber-launched cruise missiles, would also reflect a judgment that the additional capabilities provided by these sophisticated weapon systems would not be worth their cost. The forces appropriate for a policy of finite deterrence would cost about $111 billion (in fiscal year 1978 dollars) from fiscal year 1979 to fiscal year 2000, $91 billion for operating and $20 billion for investment. Operating the bomber force, at a cost of over $50 billion, is by far the largest part of total operating costs, while the completion of the Trident submarine program, at a cost of over $16 billion, accounts for most of the investment costs. The forces and cost for a policy of finite deterrence are presented in Table 6.

SLOW COUNTERFORCE

Cruise missiles could provide the United States with a "slow" counterforce capability, one that could be used in a second-strike attack against Soviet ICBMs without posing a first-strike threat to the Soviet Union's land-based missile force. Many analysts believe that a U.S. ability to carry out a second-strike counterforce attack would enhance deterrence of a Soviet first strike against vulnerable U.S. strategic forces such as silo-based missiles. They believe that without such a capability the United States would have few attractive ways to retaliate for a Soviet

TABLE 6. COSTS OF FORCES FOR FINITE DETERRENCE: BY FISCAL YEARS

	(In Millions of Current Dollars) 1979	1980	1981	1982	1983	(In Millions of FY 1978 Dollars) 1979 through 2000
Present Force of 450 Minuteman II, 550 Minuteman III, 54 Titan II						
Operating	850	910	960	1,020	1,080	17,600
20 Trident Submarines with 640 Trident I Missiles						
Investment a/	2,520	3,550	3,050	3,010	3,240	16,400
Operating b/	1,170	1,300	1,370	1,410	1,450	20,200
165 B-52s with 3,300 Cruise Missiles, c/ and 165 B-52s and 60 FB-111s with SRAM and Bombs						
Investment	0	0	760	1,000	1,060	4,100 d/
Operating e/	2,580	2,770	2,970	3,160	3,380	52,900
Total	7,120	8,530	9,110	9,600	10,210	111,200
(Investment)	(2,520)	(3,550)	(3,810)	(4,010)	(4,300)	(20,500)
(Operating)	(4,600)	(4,980)	(5,300)	(5,590)	(5,910)	(90,700)

NOTES: Costs shown do not include all the costs of maintaining the strategic forces. Not included are the costs of such functions as command, control, and communications; surveillance; and strategic defense; and the costs of nuclear warheads.

Numbers of missiles and aircraft refer to equipment in operating units. Additional procurement is included in the costs to account for spares, training, and maintenance.

a/ Trident submarine costs are uncertain and could be higher than indicated. Seven Trident submarines have been authorized through fiscal year 1978. Twenty-boat Trident force costs assume a building rate of three submarines every two years through fiscal year 1980, accelerated to two submarines per year in fiscal year 1981. Number of Trident I missiles includes 160 for deployment in ten Poseidon submarines.

b/ Submarine operating costs include the Polaris/Poseidon fleet.

c/ B-52s armed with cruise missiles include 75 B-52Ds and 90 B-52Gs.

d/ The B-52 and KC-135 tanker forces will probably have to be replaced in the early 1990s. If the B-52 force is replaced with a comparable mix of advanced penetrating bombers and wide-bodied cruise missile carriers and wide-bodied aircraft replace the present tanker force, then an additional $30-40 billion (in fiscal year 1978 dollars) would have to be spent in the 1990s to maintain a strategic bomber force.

e/ Bomber operating costs include tanker support aircraft.

strike that avoided direct attacks on U.S. cities, since U.S. retaliation against Soviet cities would only guarantee Soviet attacks on U.S. cities. On the other hand, if U.S. forces that survived a Soviet first strike were capable of destroying most of the Soviet ICBMs held in reserve, then no possible gain would result from a Soviet attack, and deterrence would be enhanced.

The extreme accuracy promised by the cruise missile's terrain-matching guidance system would make these weapons very effective against hardened missile silos, while the cruise missile's low-level flight and small size would provide the Soviet Union with a difficult air defense task. At the same time, because bomber-launched cruise missiles would take several hours to reach their targets, thus providing a "slow" counterforce capability, they would probably not pose a first-strike threat to the Soviet Union's silo-based ICBM force. As a result, the Soviets would feel little pressure to launch a preemptive strike if war were believed to be imminent. Similarly, a large U.S. cruise missile force might not threaten arms control stability, since steps to compensate for the vulnerability of Soviet silo-based ICBMs would not be necessary. Reliance on cruise missiles for a retaliatory counterforce strike, however, would make permanent SALT restrictions on cruise missile range unacceptable to the United States. The counting of bombers carrying cruise missiles as MIRVed delivery vehicles would require that older MIRVed Minuteman III or Poseidon missiles be retired as new cruise missile carriers are added to the U.S. force.

The long flight time of a slow counterforce weapon such as the cruise missile might increase the risk that the Soviets would launch some or all of their reserve ICBMs in a second-round attack before they could be destroyed by counterattacking U.S. cruise missiles. The utility of such a response is, however, debatable. Since the Soviets would have already attacked the U.S. ICBM force, the number of appropriate targets for a second-round Soviet attack would be limited. Attacks on U.S. cities would serve little purpose, since the United States would then have little incentive to continue to refrain from retaliation against Soviet cities.

A slow counterforce policy would, during the period from fiscal year 1979 through fiscal year 2000, add about $14 billion (in fiscal year 1978 dollars) to the $111 billion costs for a policy of finite deterrence. Procurement of 4,800 extra cruise missiles and 75 cruise missile carriers for the second-strike counterforce role would cost about $10 billion, while $4 billion would be required to operate this force. The forces appropriate for a slow counterforce policy and their costs are presented in Table 7.

TABLE 7. COSTS OF FORCES FOR SLOW COUNTERFORCE: BY FISCAL YEARS

	(In Millions of Current Dollars) 1979	1980	1981	1982	1983	(In Millions of FY 1978 Dollars) 1979 through 2000
75 Wide-Bodied Cruise Missile Carriers and 4,800 Cruise Missiles						
Investment	0	0	0	0	0	10,400
Operating	0	0	0	0	0	3,900
Present Force of 450 Minuteman II, 550 Minuteman III, and 54 Titan II						
Operating	850	910	960	1,020	1,080	17,600
20 Trident Submarines with 640 Trident I Missiles						
Investment a/	2,520	3,550	3,050	3,010	3,240	16,400
Operating b/	1,170	1,300	1,370	1,410	1,450	20,200
165 B-52s with 3,300 Cruise Missiles, c/ and 165 B-52s and 60 FB-111s with SRAM and Bombs						
Investment	0	0	760	1,000	1,060	4,100 d/
Operating e/	2,580	2,770	2,970	3,160	3,380	52,900
Total	7,120	8,530	9,110	9,600	10,210	125,500
(Investment)	(2,520)	(3,550)	(3,810)	(4,010)	(4,300)	(30,900)
(Operating)	(4,600)	(4,980)	(5,300)	(5,590)	(5,910)	(94,600)

NOTES: Costs shown do not include all the costs of maintaining the strategic forces. Not included are the costs of such functions as command, control, and communications; surveillance; and strategic defense; and the costs of nuclear warheads.

Numbers of missiles and aircraft refer to equipment in operating units. Additional procurement is included in the costs to account for spares, training, and maintenance.

a/ Trident submarine costs are uncertain and could be higher than indicated. Seven Trident submarines have been authorized through fiscal year 1978. Twenty-boat Trident force costs assume a building rate of three submarines every two years through fiscal year 1980, accelerated to two submarines per year in fiscal year 1981. Number of Trident I missiles includes 160 for deployment in ten Poseidon submarines.

b/ Submarine operating costs include the Polaris/Poseidon fleet.

c/ B-52s armed with cruise missiles include 75 B-52Ds and 90 B-52Gs.

d/ The B-52 and KC-135 tanker forces will probably have to be replaced in the early 1990s. If the B-52 force is replaced with a comparable mix of advanced penetrating bombers and wide-bodied cruise missile carriers and wide-bodied aircraft replace the present tanker force, then an additional $30-40 billion (in fiscal year 1978 dollars) would have to be spent in the 1990s to maintain a strategic bomber force.

e/ Bomber operating costs include tanker support aircraft.

PROMPT COUNTERFORCE

The MX ICBM and the Trident II submarine-launched missile, both highly accurate ballistic missiles planned for future deployment in survivable basing systems, would provide a "prompt" counterforce capability, one that would provide the means to retaliate against reserve Soviet ICBMs within minutes of a Soviet first strike. Such a prompt counterforce capability would give the Soviets little time to launch a second-round attack before the arrival of counterattacking U.S. missiles. In addition, because of both physical difficulties and treaty restrictions, it is unlikely that defenses against ballistic missiles could be developed.

A prompt counterforce policy would be based on the belief that such a capability, if deployed in survivable basing systems such as underground tunnels or Trident submarines, would enhance, rather than undermine, strategic stability. Because survivable U.S. counterforce weapons would not be vulnerable to a Soviet preemptive strike designed to knock out U.S. missiles threatening to their own silo-based ICBMs, the Soviets would have little to gain from a first strike. In fact, since U.S. counterforce weapons would be capable of destroying the Soviet ICBMs remaining after an attack on the United States, and since other U.S. weapons would be able to retaliate against Soviet cities, the Soviet Union would have much to lose from an attack on the United States.

U.S. counterforce weapons threatening to Soviet silo-based ICBMs might also contribute to arms control efforts for two reasons. First, the prospect of such a threat might force the Soviet Union into an agreement that limited the counterforce threat. Second, if an agreement could not be reached, such a threat might encourage the Soviets to abandon their large silo-based ICBMs for systems that would be more survivable and less threatening to the United States. In either of these cases, both sides would be prevented from gaining an ability to attack the other's land-based missiles, and stability would be enhanced.

Permanent SALT limitations on missile flight tests designed to prevent improvements in Soviet counterforce capability would also restrict U.S. development of MX and Trident II missiles, and a ban on mobile missiles would eliminate a trench- or shelter-based MX option. Limitations on the number of launchers that can be equipped with multiple warheads would not significantly affect either the MX or the Trident II option, since older MIRVed weapons, such as Minuteman III ICBMs or Poseidon SLBMs, could be retired as new systems are deployed.

During the period from fiscal year 1979 through fiscal year 2000, a policy of prompt counterforce would add almost $30 billion (in fiscal year 1978 dollars) to the $111 billion costs for a policy of finite deterrence. Procurement of 300 MX mobile missiles would cost about $23 billion for investment and $5.5 billion for operating during this period. Twelve extra Trident submarines and 768 Trident II missiles would cost about $25 billion for investment and $3.5 billion for operating. The forces and costs for a policy of prompt counterforce are presented in Table 8.

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TABLE 8. COSTS OF FORCES FOR PROMPT COUNTERFORCE: BY FISCAL YEARS

	(In Millions of Current Dollars) 1979	1980	1981	1982	1983	(In Millions of FY 1978 Dollars) 1979 through 2000
			(MX Option)			
300 MX Missiles in 3,600 Miles of Trench						
Investment a/	210	600	1,230	1,830	1,700	22,900
Operating	0	0	0	0	0	5,400
Force of 450 Minuteman II, 250 Minuteman III, and 54 Titan II						
Operating b/	850	910	960	1,020	1,080	14,500
20 Trident Submarines with 640 Trident I Missiles						
Investment c/	2,520	3,550	3,050	3,010	3,240	16,400
Operating d/	1,170	1,300	1,370	1,410	1,450	20,200
165 B-52s with 3,300 Cruise Missiles, e/ and 165 B-52s and 60 FB-111s with SRAM and Bombs						
Investment	0	0	760	1,000	1,060	4,100 f/
Operating g/	2,580	2,770	2,970	3,160	3,380	52,900
Total	7,330	9,130	10,340	11,430	11,910	136,400
(Investment)	(2,730)	(4,150)	(5,040)	(5,840)	(6,000)	(43,400)
(Operating)	(4,600)	(4,980)	(5,300)	(5,590)	(5,910)	(93,000)

(continued)

NOTES: Costs shown do not include all the costs of maintaining the strategic forces. Not included are the costs of such functions as command, control, and communications; surveillance; and strategic defense; and the costs of nuclear warheads.

Numbers of missiles and aircraft refer to equipment in operating units. Additional procurement is included in the costs to account for spares, training, and maintenance.

a/ MX cost, especially the cost to construct underground trenches, is uncertain at the present time. Costs shown assume trench cost of $2 million per mile.

b/ Three hundred Minuteman III missiles are assumed to be retired as MX missiles are deployed.

c/ Trident submarine costs are uncertain and could be higher than indicated. Seven Trident submarines have been authorized through fiscal year 1978. Twenty-boat Trident force costs assume a building rate of three submarines every two years through fiscal year 1980, accelerated to two submarines per year in fiscal year 1981. Number of Trident I missiles includes 160 for deployment in ten Poseidon submarines.

TABLE 8. (CONTINUED)

	(In Millions of Current Dollars) 1979	1980	1981	1982	1983	(In Millions of FY 1978 Dollars) 1979 through 2000
			(Trident II Option)			
32 Trident Submarines and 768 Trident II Missiles						
Investment h/	2,630	3,430	3,690	5,200	6,050	41,500
Operating d/	1,170	1,300	1,370	1,410	1,450	23,800
Present Force of 450 Minuteman II, 550 Minuteman III, and 54 Titan II						
Operating	850	910	960	1,020	1,080	17,600
165 B-52s with 3,300 Cruise Missiles, e/ and 165 B-52s and 60 FB-111s with SRAM and Bombs						
Investment	0	0	760	1,000	1,060	4,100 f/
Operating g/	2,580	2,770	2,970	3,160	3,380	52,900
Total	7,230	8,410	9,750	11,790	13,020	139,900
(Investment)	(2,630)	(3,430)	(4,450)	(6,200)	(7,110)	(45,600)
(Operating)	(4,600)	(4,980)	(5,300)	(5,590)	(5,910)	(94,300)

d/ Submarine operating costs include the Polaris/Poseidon fleet.

e/ B-52s armed with cruise missiles include 75 B-52Ds and 90 B-52Gs.

f/ The B-52 and KC-135 tanker forces will probably have to be replaced in the early 1990s. If the B-52 force is replaced with a comparable mix of advanced penetrating bombers and wide-bodied cruise missile carriers and wide-bodied aircraft replace the present tanker force, then an additional $30-40 billion (in fiscal year 1978 dollars) would have to be spent in the 1990s to maintain a strategic bomber force.

g/ Bomber operating costs include tanker support aircraft.

h/ Trident submarine costs are uncertain and could be higher than indicated. Seven Trident submarines have been authorized through fiscal year 1978. Thirty-two boat Trident force costs assume a building rate of three submarines every two years through fiscal year 1980, accelerated to three submarines per year in fiscal year 1982. Costs include the procurement of 500 Trident I missiles during the early 1980s, including 160 for deployment in ten Poseidon submarines.

TABLE 9. SUMMARY OF COSTS OF THREE OPTIONS: BY FISCAL YEARS

	(In Millions of Current Dollars) 1979	1980	1981	1982	1983	(In Millions of FY 1978 Dollars) 1979 through 2000
Finite Deterrence	7,120	8,530	9,110	9,600	10,210	111,200
Slow Counterforce	7,120	8,530	9,110	9,600	10,210	125,500
Prompt Counterforce						
MX Option	7,330	9,130	10,340	11,430	11,910	136,400
Trident II Option	7,230	8,410	9,750	11,790	13,020	139,900

NOTE: Costs shown do not include all the costs of maintaining the strategic forces. Not included are the costs of such functions as command, control, and communications; surveillance; and strategic defense; and the costs of nuclear warheads.

APPENDIXES

APPENDIX A. THE SNAPPER FORCE EXCHANGE MODEL

The Strategic Nuclear Attack Program for Planning and Evaluation of Results (SNAPPER), developed for the Air Force by the Rand Corporation, has been used to calculate the missile exchange results reported in this study. Using damage effects calculations derived by the Defense Intelligence Agency, the model does Monte Carlo analyses, varying both weapons performance and weapons characteristics.

Model inputs include the number of warheads per target, the number of launchers and the number of warheads per launcher, missile reliability and accuracy, warhead yield, height of burst, and target hardness. The values for missile reliability and accuracy, warhead yield, and target hardness are all allowed to vary, and the model gives as output both expected value and Monte Carlo results. Variations in yield are normally distributed. Variations in missile reliability and target hardness are both lognormally distributed and skewed to the left, while variations in missile accuracy are lognormally distributed and skewed to the right. All results presented are based on 25 model simulations.

APPENDIX B. U.S. ICBM VULNERABILITY IN THE MID-1980s

The following tables present the detailed expected results of hypothetical Soviet attacks on the U.S. ICBM force and the possible variations in these results for the mid-1980s. Only SS-18 missiles are used in the attacks. All results were derived with the use of the SNAPPER Force Exchange Model. All 90 Percent Confidence Intervals are based on 25 simulations.

TABLE B-1. ATTACK 1: ONE GROUNDBURST

	Surviving U.S. ICBMs			
	Percent	Missiles	Warheads	EMT b/
With 1,500 ft. Soviet CEP a/				
Minuteman II	59	267	267	267
Minuteman III	59	326	978	300
Titan	31	17	17	74
Total		610	1,262	641
With 1,200 ft. Soviet CEP a/				
Minuteman II	46	205	205	205
Minuteman III	46	251	753	231
Titan	19	10	10	43
Total		466	968	479

ASSUMPTIONS:

1. 264 SS-18s with eight 1.5 megaton warheads used in attack. Two warheads, both programmed to groundburst, fired at each U.S. silo. At most, one detonation per silo.

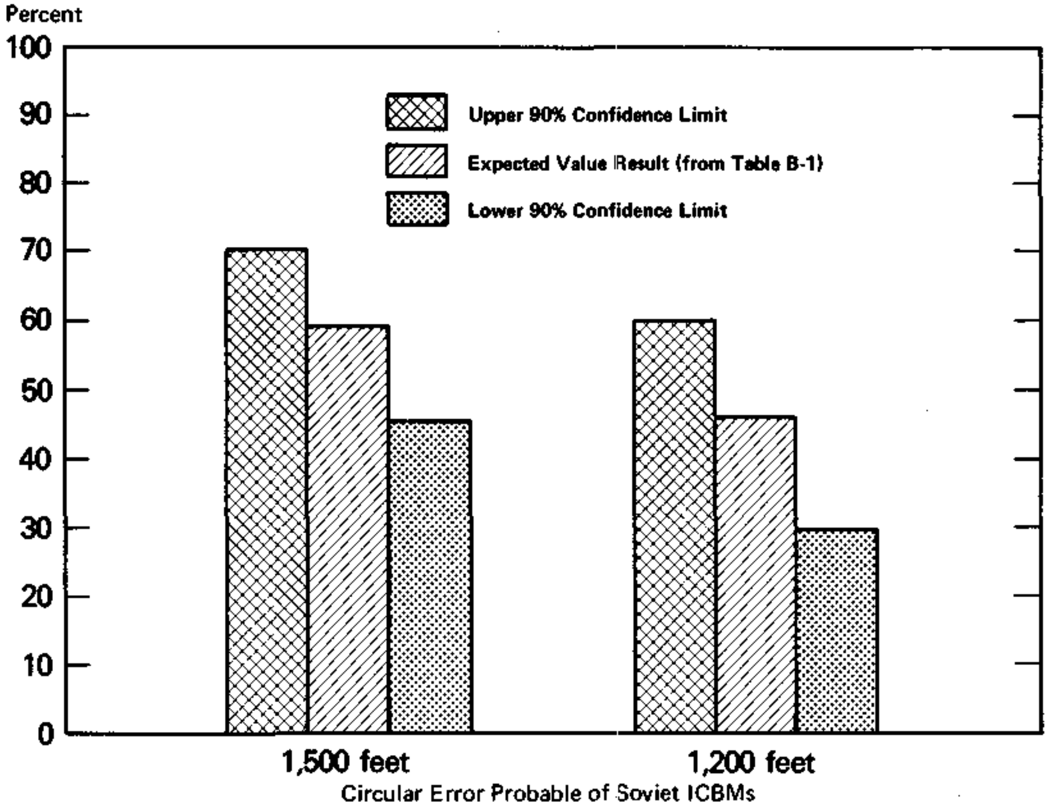
2. SS-18 reliability = 0.75; compounded reliability = 0.94.

3. Minuteman silo hardness of 2,000 pounds per square inch; 550 pounds per square inch for Titan.

a/ Circular Error Probable.

b/ Equivalent megatons.

Figure B-1.
Surviving U.S. Minuteman Force: 90 Percent Confidence Intervals for Attack 1



ASSUMPTIONS:

1. SS-18 Circular Error Probable (CEP) varies from a lower limit of 1,300 ft. to an upper 90 percent confidence level of 1,800 ft. for 1,500 ft. CEP, and from a lower limit of 1,000 ft. to an upper 90 percent confidence level of 1,500 ft. for 1,200 ft. CEP.

2. For SS-18 yield, one standard deviation equals 300 kilotons.

3. SS-18 compounded reliability varies from an upper limit of 98 percent to a lower 90 percent confidence level of 85 percent.

4. Minuteman silo hardness varies from an upper limit of 2,500 pounds per square inch to a lower 90 percent confidence level of 1,000 pounds per square inch.

TABLE B-2. ATTACK 2: ONE AIRBURST, ONE GROUNDBURST

	Surviving U.S. ICBMs			
	Percent	Missiles	Warheads	EMT b/
With 1,500 ft. Soviet CEP a/				
Minuteman II	50	224	224	224
Minuteman III	50	274	822	252.3
Titan	21	11	11	47.6
Total		509	1,057	524
With 1,200 ft. Soviet CEP a/				
Minuteman II	38	170	170	170
Minuteman III	38	207	621	190.6
Titan	14	7	7	30.3
Total		384	798	391

ASSUMPTIONS:

1. 264 SS-18s with eight 1.5 megaton warheads used in attack; cross-targeting of two warheads per silo.

2. SS-18 reliability = 0.75.

3. Height of burst for first-round airbursts is 1,600 ft. (140 scaled ft.).

4. Height of burst error of 20 percent, resulting in overall CEPs for airburst weapons of 1,650 ft. (for 1,500 ft. missile CEP) and 1,400 ft. (for 1,200 ft. missile CEP). Note: height of burst error of zero would result in Minuteman survivability of 47 percent for 1,500 ft. CEP and 33 percent for 1,200 ft. CEP.

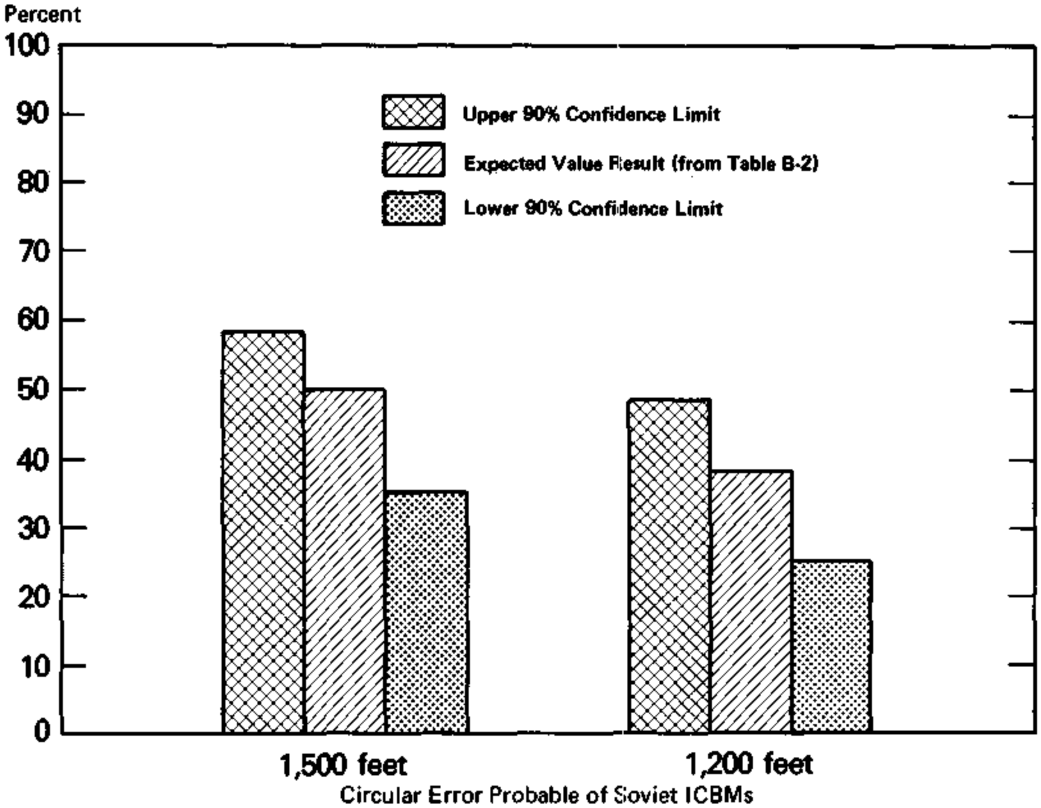
5. Minuteman silo hardness of 2,000 pounds per square inch; 550 pounds per square inch for Titan.

6. 100 percent fratricide avoidance.

a/ Circular Error Probable.

b/ Equivalent megatons.

Figure B-2.
Surviving U.S. Minuteman Force: 90 Percent Confidence Intervals for Attack 2



ASSUMPTIONS:

1. For groundburst weapons, SS-18 Circular Error Probable (CEP) varies from a lower limit of 1,300 ft. to an upper 90 percent confidence level of 1,800 ft. for 1,500 ft. CEP, and from a lower limit of 1,000 ft. to an upper 90 percent confidence level of 1,500 ft. for 1,200 ft. CEP. For airburst weapons, CEP varies from a lower limit of 1,450 ft. to an upper 90 percent confidence level of 1,950 ft. for 1,650 ft. airburst CEP, and from a lower limit of 1,200 ft. to an upper 90 percent confidence level of 1,700 ft. for 1,400 ft. air burst CEP.

2. For SS-18 yield, one standard deviation equals 300 kilotons.

3. SS-18 reliability varies from an upper limit of 85 percent to a lower 90 percent confidence level of 60 percent.

4. Minuteman silo hardness varies from an upper limit of 2,500 pounds per square inch to a lower 90 percent confidence level of 1,000 pounds per square inch.

TABLE B-3. ATTACK 3: ONE AIRBURST, ONE GROUNDBURST, AND REPROGRAMMING FOR RELIABILITY

	Surviving U.S. ICBMs			
	Percent	Missiles	Warheads	EMT b/
With 1,500 ft. Soviet CEP a/				
Minuteman II	44	200	200	200
Minuteman III	44	244	732	225
Titan	14	8	8	35
Total		452	940	460
With 1,200 ft. Soviet CEP a/				
Minuteman II	32	142	142	142
Minuteman III	32	174	522	160
Titan	8	4	4	17
Total		320	668	319

ASSUMPTIONS:

1. 264 SS-18s with eight 1.5 megaton warheads used in first wave; cross-targeting of two warheads per silo.

2. 44 remaining SS-18s used to replace as many early failures as possible (20 percent of all missiles fail through second-stage ignition and can potentially be replaced, and 5 percent fail in latter portions of flight), bringing reprogrammed reliability up to 85 percent.

3. Height of burst for first-round airbursts is 1,600 ft. (140 scaled ft.).

4. Height of burst error of 20 percent, resulting in overall CEPs for airburst weapons of 1,650 ft. (for 1,500 ft. missile CEP) and 1,400 ft. (for 1,200 ft. missile CEP). Note: height of burst error of zero would result in Minuteman survivability of 41 percent for 1,500 ft. CEP and 27 percent for 1,200 ft. CEP.

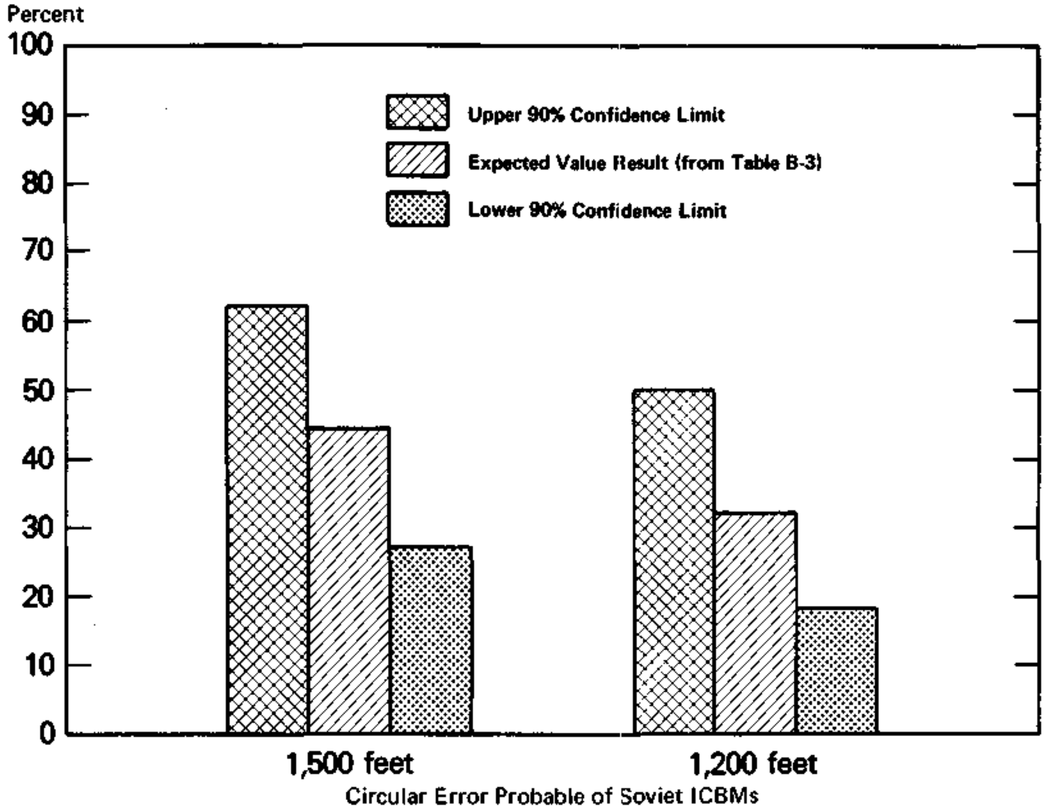
5. Minuteman silo hardness of 2,000 pounds per square inch; 550 pounds per square inch for Titan.

a/ Circular Error Probable.

b/ Equivalent megatons.

Figure B-3.

Surviving U.S. Minuteman Force: 90 Percent Confidence Intervals for Attack 3



ASSUMPTIONS:

1. For groundburst weapons, SS-18 Circular Error Probable (CEP) varies from a lower limit of 1,300 ft. to an upper 90 percent confidence level of 1,800 ft. for 1,500 ft. CEP, and from a lower limit of 1,000 ft. to an upper 90 percent confidence level of 1,500 ft. for 1,200 ft. CEP. For airburst weapons, CEP varies from a lower limit of 1,450 ft. to an upper 90 percent confidence level of 1,950 ft. for 1,650 ft. airburst CEP, and from a lower limit of 1,200 ft. to an upper 90 percent confidence level of 1,700 ft. for 1,400 ft. airburst CEP.

2. For SS-18 yield, one standard deviation equals 300 kilotons.

3. SS-18 reprogrammed reliability varies from an upper limit of 90 percent to a lower 90 percent confidence level of 80 percent.

4. Minuteman silo hardness varies from an upper limit of 2,500 pounds per square inch to a lower 90 percent confidence level of 1,000 pounds per square inch.

APPENDIX C. U.S. ICBM VULNERABILITY IN THE MID-TO-LATE-1980s

In the latter half of the 1980s, the vulnerability of the U.S. silo-based ICBMs may grow if the Soviets develop missiles similar in payload and yield to the SS-18 but capable of accuracies of 900 to 600 feet. The following tables present the results of hypothetical Soviet attacks using new generation, large ICBMs, referred to here as "SS-18 follow-ons."

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TABLE C-1. ATTACK 1: ONE GROUNDBURST

	Surviving U.S. ICBMs			
	Percent	Missiles	Warheads	EMT b/
With 900 ft. Soviet CEP a/				
Minuteman II	26	118	118	118
Minuteman III	26	144	432	132.6
Titan	8	4	4	17.3
Total		266	554	268
With 600 ft. Soviet CEP a/				
Minuteman II	9	41	41	41
Minuteman III	9	50	150	46
Titan	4	2	2	8.7
Total		93	193	96

ASSUMPTIONS:

1. 264 SS-18 follow-ons with eight 1.5 megaton warheads used in attack. Two warheads, both programmed to groundburst, fired at each U.S. silo. At most, one detonation per silo.

2. Reliability = 0.80; compounded reliability = 0.96.

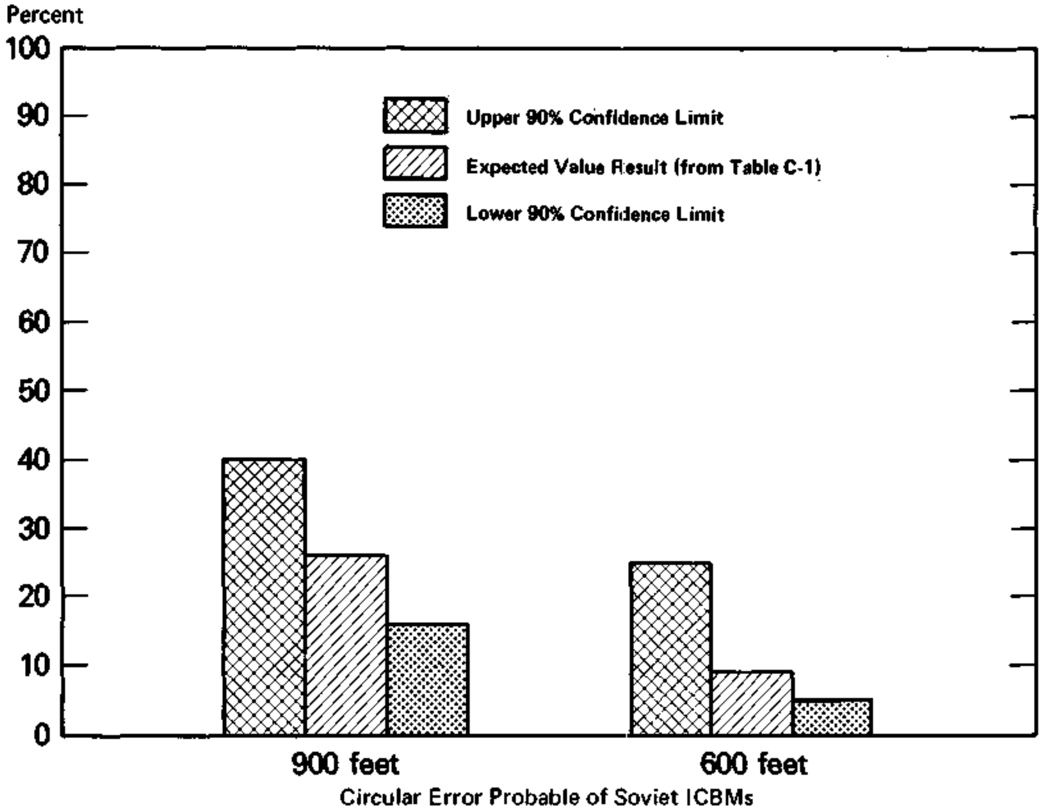
3. Minuteman silo hardness of 2,000 pounds per square inch; 550 pounds per square inch for Titan.

a/ Circular Error Probable.

b/ Equivalent megatons.

Figure C-1.

Surviving U.S. Minuteman Force: 90 Percent Confidence Intervals for Attack 1



ASSUMPTIONS:

1. SS-18 follow-on Circular Error Probable (CEP) varies from a lower limit of 800 ft. to an upper 90 percent confidence level of 1,200 ft. for 900 ft. CEP, and from a lower limit of 500 ft. to an upper 90 percent confidence level of 900 ft. for 600 ft. CEP.
2. For SS-18 follow-on yield, one standard deviation equals 300 kilotons.
3. SS-18 follow-on compounded reliability varies from an upper limit of 99 percent to a lower 90 percent confidence level of 88 percent.
4. Minuteman silo hardness varies from an upper limit of 2,500 pounds per square inch to a lower 90 percent confidence level of 1,000 pounds per square inch.

TABLE C-2. ATTACK 2: ONE AIRBURST, ONE GROUNDBURST

	Surviving U.S. ICBMs			
	Percent	Missiles	Warheads	EMT b/
With 900 ft. Soviet CEP a/				
Minuteman II	21	94	94	94
Minuteman III	21	114	342	105
Titan	6	3	3	13
Total		211	439	212
With 600 ft. Soviet CEP a/				
Minuteman II	10	45	45	45
Minuteman III	10	54	162	50
Titan	4	2	2	9
Total		101	209	104

ASSUMPTIONS:

1. 264 SS-18 follow-ons with eight 1.5 megaton warheads used in attack; cross-targeting of two warheads per silo.

2. Reliability = 0.80.

3. Height of burst for first-round airbursts is 1,600 ft.

4. Height of burst error of 20 percent, resulting in overall CEPs for airburst weapons of 1,150 ft. (for 900 ft. missile CEP) and 900 ft. (for 600 ft. missile CEP). Note: height of burst error of 10 percent would result in Minuteman survivability of 17 percent for 900 ft. CEP and 7 percent for 600 ft. CEP.

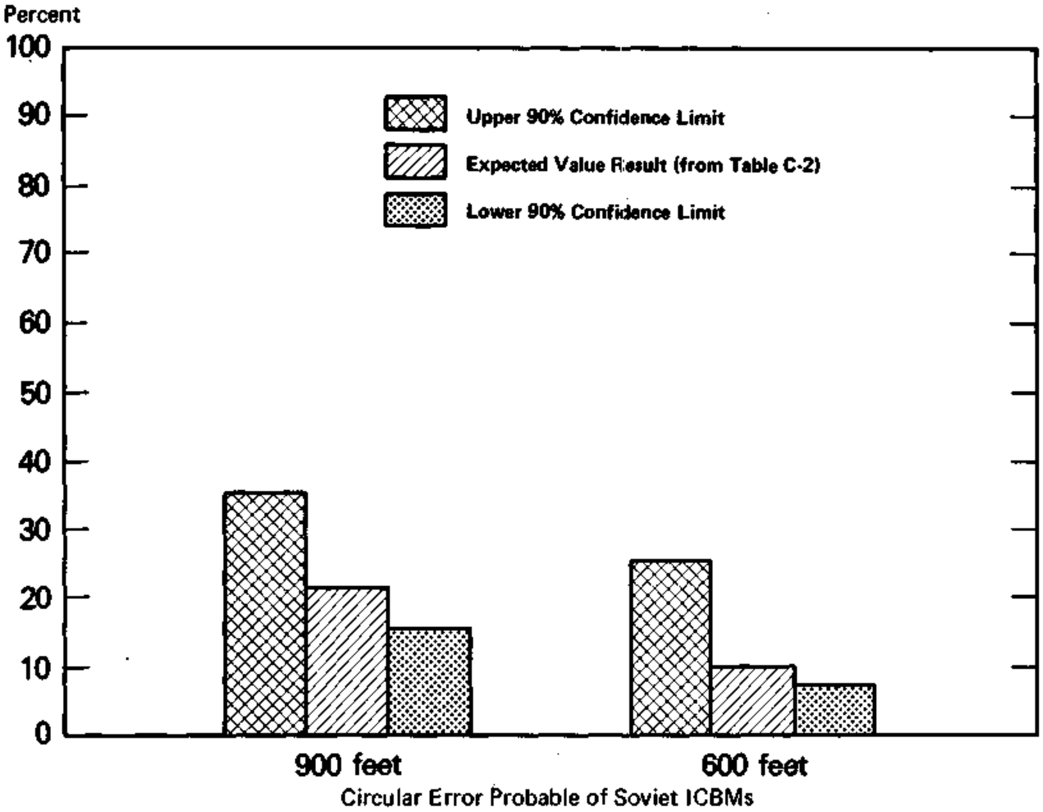
5. Minuteman silo hardness of 2,000 pounds per square inch; 550 pounds per square inch for Titan.

6. 100 percent fratricide avoidance.

a/ Circular Error Probable.

b/ Equivalent megatons.

Figure C-2.
Surviving U.S. Minuteman Force: 90 Percent Confidence Intervals for Attack 2



ASSUMPTIONS:

1. For groundburst weapons, SS-18 follow-on Circular Error Probable (CEP) varies from a lower limit of 800 ft. to an upper 90 percent confidence level of 1,200 ft. for 900 ft. CEP, and from a lower limit of 500 ft. to an upper 90 percent confidence level of 900 ft. for 600 ft. CEP. For airburst weapons, CEP varies from a lower limit of 950 ft. to an upper 90 percent confidence level of 1,450 ft. for 1,150 ft. airburst CEP, and from a lower limit of 700 ft. to an upper 90 percent confidence level of 1,200 ft. for 900 ft. airburst CEP.
2. For SS-18 follow-on yield, one standard deviation equals 300 kilotons.
3. SS-18 follow-on reliability varies from an upper limit of 90 percent to a lower 90 percent confidence level of 65 percent.
4. Minuteman silo hardness varies from an upper limit of 2,500 pounds per square inch to a lower 90 percent confidence level of 1,000 pounds per square inch.

TABLE C-3. ATTACK 3: ONE AIRBURST, ONE GROUNDBURST, AND REPROGRAMMING FOR RELIABILITY

	Surviving U.S. ICBMs			
	Percent	Missiles	Warheads	EMT b/
With 900 ft. Soviet CEP a/				
Minuteman II	15	67	67	67
Minuteman III	15	82	246	75.5
Titan	4	2	2	8.7
Total		151	315	151
With 600 ft. Soviet CEP a/				
Minuteman II	5	22	22	22
Minuteman III	5	27	81	24.9
Titan	3	1	1	4.3
Total		50	104	51

ASSUMPTIONS:

1. 264 SS-18 follow-ons with eight 1.5 megaton warheads used in first wave; cross-targeting of two warheads per silo.

2. 44 remaining follow-ons used to replace as many early failures as possible (15 percent of all missiles fail through second-stage ignition and can potentially be replaced, and 5 percent fail in latter portions of flight), bringing reprogrammed reliability up to 90 percent.

3. Height of burst for first-round airbursts is 1,600 ft.

4. Height of burst error of 20 percent, resulting in overall CEPs for airburst weapons of 1,150 ft. (for 900 ft. missile CEP) and 900 ft. (for 600 ft. missile CEP).

5. Minuteman silo hardness of 2,000 pounds per square inch; 550 pounds per square inch for Titan.

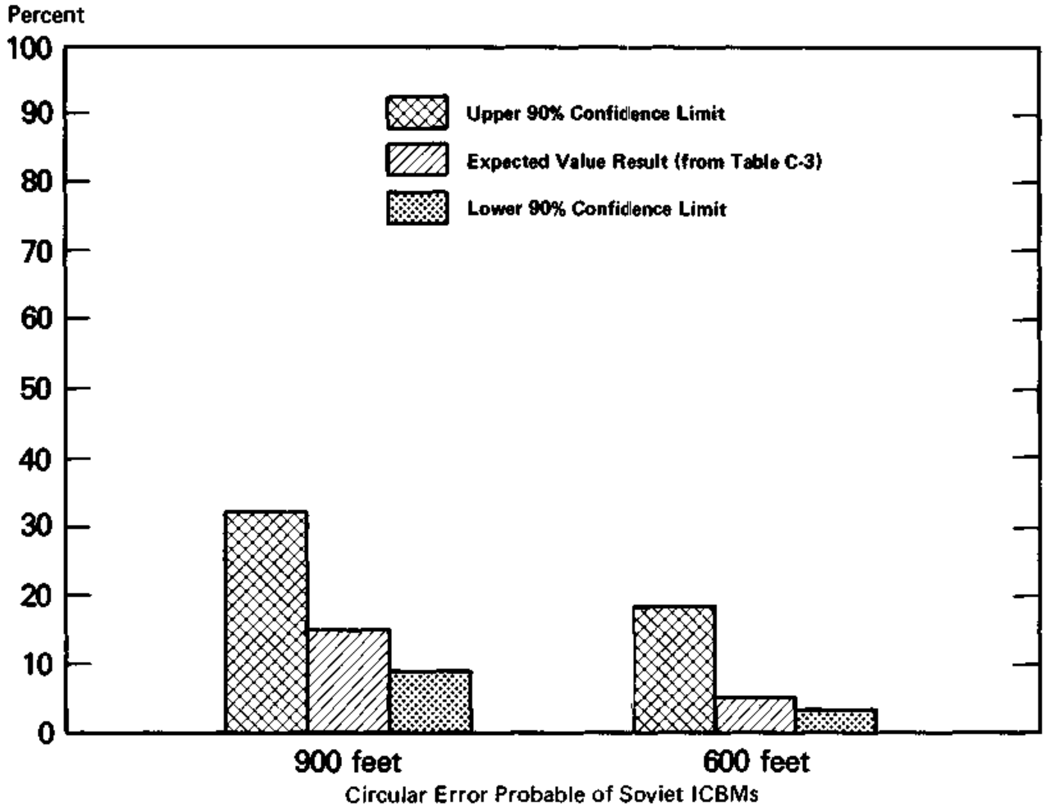
6. 100 percent fratricide avoidance.

a/ Circular Error Probable.

b/ Equivalent megatons.

Figure C-3.

Surviving U.S. Minuteman Force: 90 Percent Confidence Intervals for Attack 3



ASSUMPTIONS:

1. For groundburst weapons, SS-18 follow-on Circular Error Probable (CEP) varies from a lower limit of 800 ft. to an upper 90 percent confidence level of 1,200 ft. for 900 ft. CEP, and from a lower limit of 500 ft. to an upper 90 percent confidence level of 900 ft. for 600 ft. CEP. For airburst weapons, CEP varies from a lower limit of 950 ft. to an upper 90 confidence level of 1,450 ft. for 1,150 ft. airburst CEP, and from a lower limit of 700 ft. to an upper 90 percent confidence level of 1,200 ft. for 900 ft. airburst CEP.
2. For SS-18 follow-on yield, one standard deviation equals 300 kilotons.
3. SS-18 follow-on reprogrammed reliability varies from an upper limit of 95 percent to a lower 90 percent confidence level of 85 percent.
4. Minuteman silo hardness varies from an upper limit of 2,500 pounds per square inch to a lower 90 percent confidence level of 1,000 pounds per square inch.

Antiballistic Missile (ABM) System: A system to counter strategic ballistic missiles or their elements in flight trajectory.

Antisubmarine Warfare (ASW): Measures to detect, locate, track, and destroy submarines, currently primarily dependent upon acoustic sensors.

B-52: The mainstay of the U.S. strategic bomber force since the 1950s. About 250 late model G and H aircraft and 75 rewinged D bombers are expected to remain in the inventory until the early 1990s. Many of these will be equipped with cruise missiles in the early 1980s, while others will continue to carry gravity bombs and short-range attack missiles.

Ballistic Missile: Any missile which does not rely upon aerodynamic surfaces to produce lift and consequently follows a ballistic trajectory (that is, one resulting when the body is acted upon only by gravity and aerodynamic drag) when thrust is terminated.

Circular Error Probable (CEP): A measure of the delivery accuracy of a weapon system used as a factor in determining probable damage to targets. It is the radius of a circle around the target at which a missile is aimed within which the warhead has a 0.5 probability of falling.

Counterforce Strike: An attack aimed at an adversary's military capability, especially his strategic nuclear military capability.

Cruise Missile: A guided missile which uses aerodynamic lift to offset gravity and propulsion to counteract drag. The major portion of a cruise missile's flight path remains within the earth's atmosphere.

1/ Definitions are from SALT Lexicon, U.S. Arms Control and Disarmament Agency, 1974; and from Projected Strategic Offensive Weapons Inventories of the U.S. and USSR, Congressional Research Service, March 24, 1977.

Cruise Missile Carrier (CMC): An aircraft capable of delivering cruise missiles to within range of their targets. Current plans call for the use of B-52 bombers in this role. In the mid-1980s, wide-bodied commercial aircraft may be procured to supplement, and eventually replace, the B-52 force.

Depressed Trajectory: The trajectory of a ballistic missile fired at an angle to the ground significantly lower than the angle of minimum energy trajectory. A method of reducing missile flight time.

Electronic Countermeasures (ECM): Measures used by bombers or other aircraft to negate the effectiveness of enemy air defense radars, surface-to-air missiles, and interceptor aircraft.

Equivalent Megatons (EMT): A commonly used measure of the urban area destructive power of a nuclear weapon that accounts for the fact that area destructive power does not increase proportionately with increases in yield. It is expressed by the relationship EMT = N multiplied by Y to the 2/3 power, where N is the number of weapons of yield Y.

FB-111: Medium bombers procured in small numbers in the late 1960s to supplement the B-52 force. Although capable of supersonic low-level flight, the aircraft's small range and payload limits its effectiveness. Modified stretched FB-111H bombers may be added to the bomber force in the 1980s.

First Strike (nuclear): The launching of an initial strategic nuclear attack before the opponent has used any strategic weapons himself.

Fratricide: The destruction of warheads entering an area where previous nuclear explosions have recently taken place, especially during a large-scale attack on a small area.

Generated Alert: A condition when forces are placed in a high state of readiness, with the vast majority of the bomber force on ground alert ready for rapid take-off and the vast majority of the submarine force at sea.

Global Positioning Satellites (GPS): A system of orbiting satellites that will be able to give ships, aircraft, missiles, and other vehicles precise information on their position and velocity by the early 1980s.

Hardness: The amount of protection afforded by structural shielding against blast, heat, and radiation effects of nuclear explosions, usually measured in pounds per square inch (PSI).

Inertial Guidance: A system that measures acceleration by means of gyros and relates it to distances traveled in certain directions. Designed to steer ballistic missiles over predetermined courses, using data generated solely by devices in the missiles.

Intercontinental Ballistic Missile (ICBM): A land-based, rocket-propelled vehicle capable of delivering a warhead to intercontinental ranges (ranges in excess of about 3,000 nautical miles).

Kiloton (KT): The yield of a nuclear weapon equivalent to 1,000 tons of TNT.

Megaton (MT): The yield of a nuclear weapon equivalent to 1,000,000 tons of TNT.

Minuteman: The mainstay of the U.S. ICBM force since the early 1960s. At the present time, the United States maintains a force of 450 single-warhead Minuteman II missiles and 550 three-warhead Minuteman III missiles.

MK-12A: A higher yield, more accurate warhead designed to replace the MK-12 warhead presently deployed on Minuteman III missiles. MK-12A warheads may also be deployed on MX ICBMs and Trident II SLBMs.

Multiple Independently Targetable Reentry Vehicle (MIRV): Two or more reentry vehicles carried by a single missile and capable of being independently targeted.

MX: A more powerful, more accurate ICBM now in the research and development stage that may supplement the Minuteman force in the mid-1980s. Current plans call for mobile basing for MX missiles. Missiles would be moved either within underground protective trenches or among protective above-ground shelters.

Payload: The weapon and/or cargo capacity of any aircraft or missile system, expressed variously in pounds, in number of weapons, and in terms of missile warhead yields.

Polaris: U.S. submarines that carry the first generation of submarine-launched Polaris missiles. Each submarine can carry 16 missiles. Expected to begin leaving the force in the early 1980s.

Poseidon: U.S. submarines that carry the first generation of multiple-warhead, submarine-launched Poseidon missiles. Each submarine can carry 16 missiles. The thousands of warheads carried by these 31 submarines comprise the most survivable element of the U.S. nuclear retaliatory capability. Expected to be replaced by Trident submarines during the late 1980s and early 1990s.

Reentry Vehicle (RV): That portion of a ballistic missile designed to carry a nuclear warhead and to reenter the earth's atmosphere in the terminal portion of the missile trajectory.

Seafarer: An Extremely Low Frequency (ELF) U.S. Navy communications system for submarines that would allow receipt of messages without the necessity of bringing submarines close to the surface, where they are most vulnerable. Presently in the research and development stage, Seafarer could be constructed in the early 1980s.

Second Strike: A term usually used to refer to a retaliatory attack in response to a first strike.

Silo: Underground facilities for a hard-site ballistic missile and/or crew, designed to provide prelaunch protection against nuclear effects.

Short-Range Attack Missile (SRAM): An air-to-surface missile carried by U.S. FB-111 and B-52 bombers.

SS-18: A large Soviet surface-to-surface missile. The largest ICBM in the world, the SS-18 can carry eight to ten megaton-range warheads. Now being deployed, about 300 SS-18s may eventually replace older, single-warhead SS-9s. Smaller SS-19s and SS-17s, both multiple-warhead missiles, are currently replacing older, single-warhead SS-11s.

SSBN: Nuclear-powered ballistic missile submarine.

Strategic Stability: Strategic stability encompasses both crisis stability and arms stability, and refers to a relationship in which neither side has an incentive to initiate the use of strategic nuclear forces in a crisis or perceives the necessity to undertake major new arms programs to avoid being placed at a strategic disadvantage.

Submarine-Launched Ballistic Missile (SLBM): A ballistic missile carried in and launched from a submarine.

Surface-to-Air Missile (SAM): A surface-launched missile employed to counter airborne threats.

Throw-Weight: Ballistic missile throw-weight is the maximum useful weight which has been flight tested on the boost stages of the missile. The useful weight includes weight of the reentry vehicles, penetration aids, dispensing and release mechanisms, guidance devices, reentry shrouds, covers, buses, and propulsion devices with their propellants (but not the final stages) that are present at the end of the boost phase.

TRIAD: The term used in referring to the basic structure of the U.S. strategic deterrent force. It is comprised of land-based ICBMs, the strategic bomber force, and the Polaris/Poseidon submarine fleet. (Trident submarines will join the force in the early 1980s.)

Trident: U.S submarines now under construction that are expected to replace the Polaris/Poseidon fleet. Each submarine will be able to carry 24 Trident I or Trident II missiles. The Trident II missile, now entering research and development, will provide an option to improve the accuracy and increase the destructive power of the sea-based nuclear force in the mid-to-late 1980s.

Warheads: That part of a missile, projectile, or torpedo that contains the explosive intended to inflict damage.

Yield: The force of a nuclear explosion expressed in terms of the number of tons of TNT that would have to be exploded to produce the same energy.